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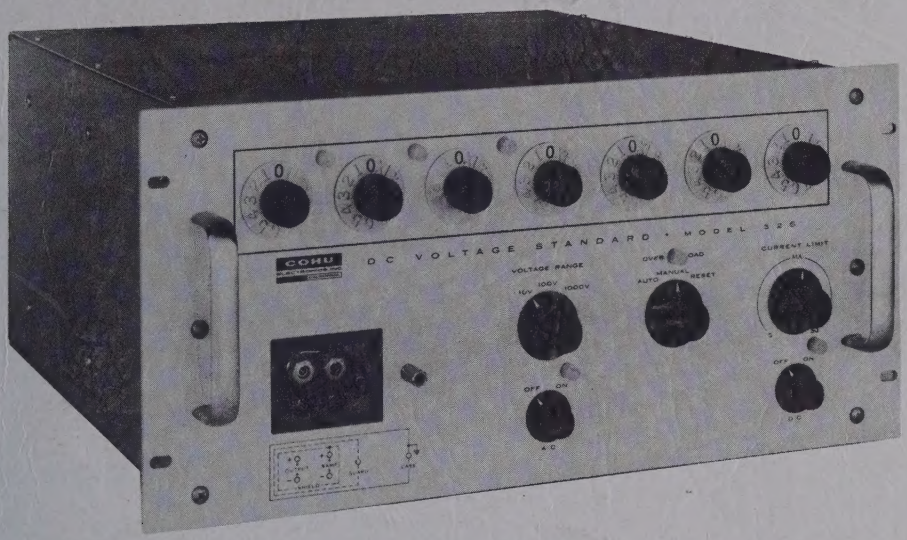

OPERATING AND MAINTENANCE INSTRUCTIONS FOR

DC VOLTAGE STANDARD

MODEL 326

PROPERTY OF
DEPT.

Box 623 / San Diego, California 92112 / Phone (714) 277-6700

COHU
ELECTRONICS, INC
SAN DIEGO DIVISION

MANUAL PRICE $10.00

Technical Manual
Code No. 15X-70

OPERATING AND MAINTENANCE INSTRUCTIONS FOR MODEL 326 DC VOLTAGE STANDARD

SERIAL NUMBERS 1-0101 THROUGH 1-0175

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COHU ELECTRONICS, INC.
Box 623, San Diego, California 92112

12-1-66

INSTRUCTION MANUAL CHANGES

MODEL 326 DC VOLTAGE STANDARD 15X-70

CHANGE NO. 1
12-1-66

SERIAL NUMBERS 1-0101 AND HIGHER

Protective Circuit Board. Diode CR804 removed.

Power Supply Circuit Board. Resistors R233 and R234 changed to 33K, 5%, 2W, COHU Part No. 0310032-333 and R235 changed to 330K, 5%, 1W, COHU Part No. 0310031-334, and mounted vertically. R235 is removed from between the Q201 base and junction R233/R234/R216/R217 and connected between the Q201 base and junction R234/R214/C201B/terminal 36.

These changes affect Figures 3-9, 4-15, and 4-16, and Table 4-1 pages 4-23 and 4-24.

COHU
ELECTRONICS, INC
SAN DIEGO DIVISION

INSTRUCTION MANUAL CHANGES

MODEL 323 DC VOLTAGE STANDARD

323-10

CHANGE NO. 1
3-1-66

SERIAL NUMBERS 1-0101 AND HIGHER

Protective Circuit Board. Diode CR804 removed.

Power Supply Circuit Board. Resistors R233 and R234 changed to 330K, 5%, 2W, COHU Part No. 031033-334, 330K, 5%, 1W, COHU Part No. 031033-334, and mounted vertically. R235 is removed from between the Q201 base and junction R233/R234/R216/R217 and connected between the Q201 base and junction R233/R234/R216/R217/R218/terminal 3B.

These changes affect Figures 3-9, 4-15, and 4-16, and Table 4-1 pages 4-23 and 4-24.

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Section I
GENERAL DESCRIPTION

1–1. INTRODUCTION

The Model 326 DC Voltage Standard is an exceptionally accurate and stable source of dc voltage. Output voltages from 0.000000 volts to ±1222.2221 volts are selected by a range switch and seven decade switches. The range switch has nominal full-scale ranges of 10, 100, and 1000 volts. The decade switches are of the detented, bidirectional, make-before-break, rotary type. The selected output voltage is indicated by the decade switch dials, which provide an in-line readout with illuminated decimal point placement.

The output current capability of the instrument is 50 milliamperes at any voltage setting. A continuously variable front panel control permits the output current to be limited within the range of 5 to 50 milliamperes. The instrument has a protective circuit which de-energizes the output terminals if the output current exceeds the set limit or if an overvoltage condition occurs. Dependent on the setting of a front panel control the protective circuit resets automatically or it can be reset manually. The output terminals can also be de-energized by means of a front panel control. Indicators show when the instrument is energized, when the output terminals are energized, and when the instrument is overloaded.

1–2. PHYSICAL DETAILS

The instrument is designed for bench use and for mounting in a standard, 19-inch rack or cabinet, and has provision for installing slides. All operating controls, indicating lights, and binding posts are mounted on the front panel. The primary power entry and fuse are located at the rear. Ventilation is provided by a fan in the rear of the instrument.

1–3. SHIELDING

The circuitry of the instrument is shielded by a box-within-a-box system of construction. As shown in Figure 1-1, the ac-power input and the primary winding of the power transformer are enclosed by shielding that is grounded via the case of the instrument through the ground lead of the ac-power input cable. The primary shield is enclosed by a guard shield which is connected to the front panel GUARD terminal. The shielding of the secondary windings of the power transformer is connected to circuit common and to the chassis, which encloses the circuitry of the instrument including the power transformer, and is connected to the +SAMPLING terminal. The isolated output of the instrument is therefore well shielded from the ac-power line and the case. The output can be applied to isolated or grounded loads.

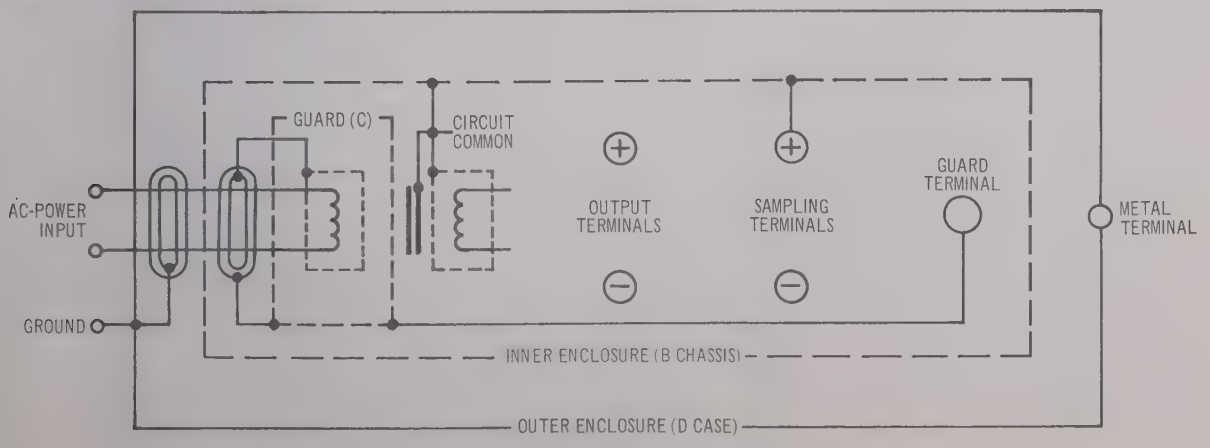


Figure 1-1. Shielding System

1–4. COMPONENTS

The instrument includes electron-tube and solid-state circuits, the majority of which are located on etched-circuit boards. Most of the components are mounted on boards which are secured horizontally at the bottom of the chassis by screws. Other components are on a vertically-mounted, plug-in board. The remaining components are mounted immediately behind the front panel.

1–5. CONSTRUCTION

Details of the materials used in the construction of the instrument are as follows:

Etched-circuit boards – epoxy glass or paper base epoxy laminate

Chassis and front panel – aluminum

Case and chassis cover plates – cold rolled steel

1–6. FINISH

The structural parts of the instrument are finished as follows:

Chassis – clear alodine

Chassis cover plates – cadmium plated

Front panel – clear alodine, outside painted semi-gloss light gray enamel COHU No. 3310042-218 (color No. 26492 per FED-STD-595), silk screened in black

Case – cadmium plated, outside painted medium gray medium wrinkle enamel COHU No. 3310042-418 (color No. 26251 per FED-STD-595)

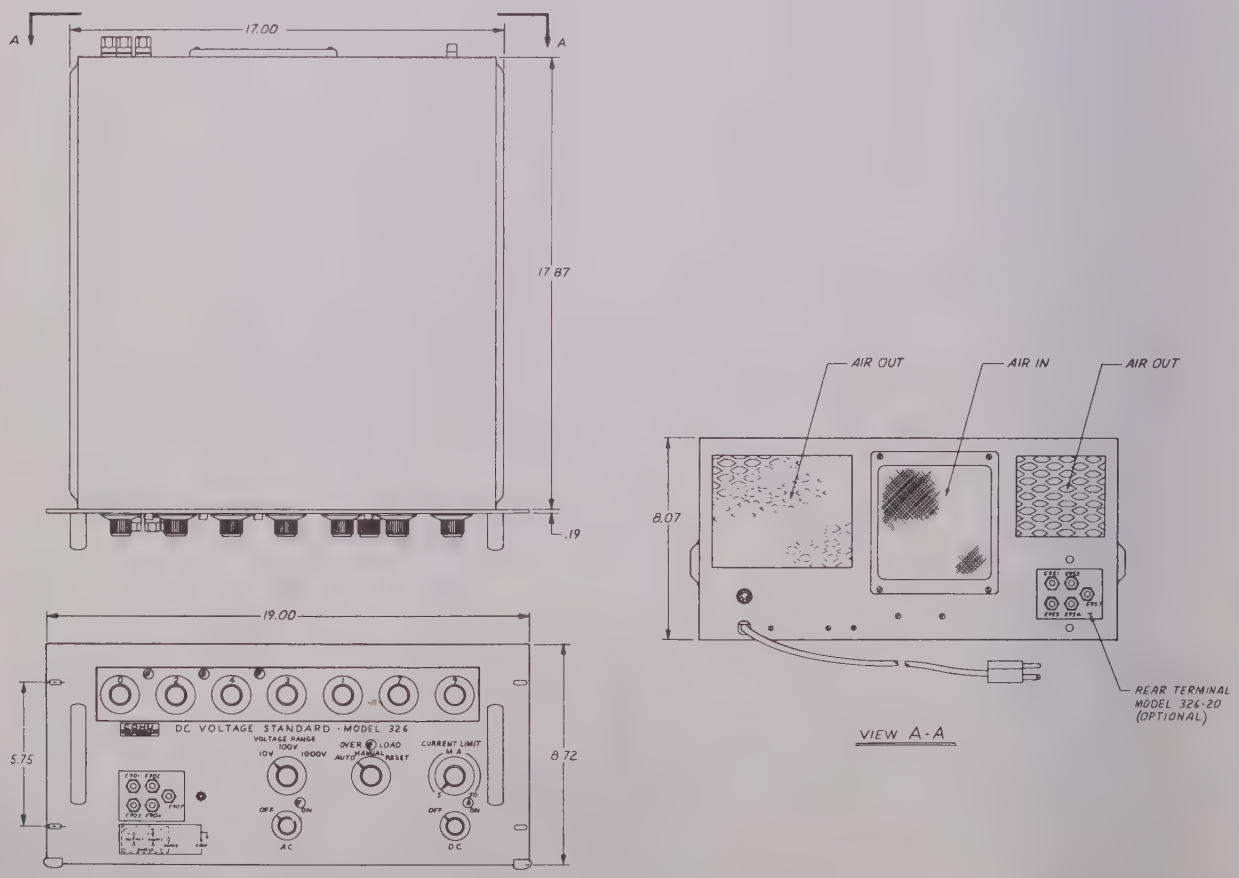


Figure 1-2. Dimensions and Outline

1–7. DIMENSIONS AND WEIGHT

The dimensions and weight of the instrument are as follows:

Net weight – 50 pounds

Shipping weight – 70 pounds

Dimensions – see Figure 1-2

1–8. ELECTRICAL SPECIFICATIONS

The electrical specifications of the instrument are listed in Table 1-1.

1–9. ACCURACY

For a period of six months after calibration the output voltage, referred to the volt maintained by the National Bureau of Standards, is equal to the set value, within the tolerances specified in Table 1-1, 99.7 percent of the time for a constant external load and the standard reference conditions listed in paragraph 1-11. The accuracy specification includes the effects of the stability specifications and all the specifications within the ranges of the variables in the list of specifications in Table 1-1.

1–10. STABILITY

For any 7-day period the output voltage is within 15 parts per million of its mean value plus 1 part per million of full scale to 20 microvolts 99.7 percent of the time. For any 6-month period the output voltage is within 25 parts per million of its mean value plus 1 part per million of full scale to 40 microvolts 99.7 percent of the time. The stability specifications apply for a constant external load and the standard reference conditions listed in paragraph 1-11.

1–11. STANDARD REFERENCE CONDITIONS

The accuracy and stability specifications listed in Table 1-1 apply for a constant external load and the following standard reference conditions:

Ambient temperature, 23 ±1°C

Relative humidity, ≤55 percent

Atmospheric pressure, 575 to 800 millimeters of mercury

Line voltage, nominal ±1 volt rms

Line frequency, nominal ±0.5 Hz

1–12. ACCURACY AND STABILITY MEASUREMENTS

The accuracy and stability measurements are made using a low-pass filter or measuring system having a cut-off frequency of 0.1 Hz or less and a slope of 20 dB per decade or more to over 60 dB down.

Table 1-1. Electrical Specifications

OUTPUT VOLTAGE	0.000000 to ±1000.0000 volts in 3 decade ranges (±1222.2221 volts at maximum overrange)
OUTPUT CURRENT	0 to 50 milliamperes at any voltage setting (Current may be limited by protective circuitry within the range of 5 mA to 50 mA as determined by the setting of a current-limit control on the front panel)
ACCURACY (Refer to para. 1-9)	10V range, 0.003% of setting plus 10 μV 100V range, 0.003% of setting plus 20 μV 1000V range, 0.003% of setting plus 40 μV
STABILITY (Refer to para. 1-10)	<0.1 Hz: 7 days, 0.0015% of setting plus (0.0001% of full scale to 20 μV) 6 months, 0.0025% of setting plus (0.0001% of full scale to 40 μV)
NOISE AND HUM (RMS noise voltage)	0.1 to 10 Hz: <(6 x 10^{-8} E_o plus 5 μV) on all ranges 10 to 750 Hz: 10V range, <20 μV 100V range, <30 μV 1000V range, <40 μV
SOURCE RESISTANCE	<(0.00025 plus 0.00005 E_o) ohm at dc
LOAD REGULATION	<(0.00025% of setting plus 12.5 μV) no load to full load
LINE REGULATION	<(0.001% of setting plus 10 μV) for a 10% change from nominal ac-line voltage
TEMPERATURE COEFFICIENT	<(2 ppm plus 1 μV)/°C from +20° to +40°C
POWER REQUIREMENTS	105-125 or 210-250 V, 50-60 Hz, 220 VA maximum, 180W maximum

COHU reserves the right to change specifications without notice.

Section II
OPERATION

2–1. INITIAL CHECK

The operation of the instrument should be checked upon receipt to detect possible concealed damage caused during shipment (refer to form P-293-5-62-5M enclosed with instrument). Check the instrument in accordance with the information and instructions in this section. A procedure for functionally checking the instrument is given in paragraph 2-10.

2–2. INSTALLATION

The instrument may be mounted in a standard, 19-inch rack or cabinet, or it can be used as a bench unit. For proper ventilation, allow a clearance of at least three inches at the rear of the instrument.

2–3. PRIMARY-POWER CONNECTION

Connect the instrument to a three-contact outlet so that the case is grounded through the ground lead of the ac-power cable. If the instrument is operated from a two-contact outlet, use a three-contact adapter with a pigtail and connect the pigtail to ground. The instrument is connected for 115-volt operation unless 220-volt operation is specified on order.

2–4. TERMINAL CONNECTIONS

The instrument has six terminals on the front panel which will accept spade lugs and banana plugs. The two terminals designated OUTPUT furnish current, and the two terminals designated SAMPLING permit the voltage across the load to be sampled. The terminal designated GUARD may be connected to the low side of the load or driven by external circuitry to increase the effective common-mode impedance. The metal terminal may be used to ground the load. The terminals can be connected to provide either two-terminal or four-terminal outputs which may be applied to isolated or grounded loads.

2–5. TWO-TERMINAL OUTPUT

Two-terminal output may be used when the load is near the instrument or for high-resistance loads. For two-terminal positive output, connect the load to the terminals as shown in Figure 2-1; for a negative output connect the load as shown in Figure 2-2. Omit the ground connection if a load is already grounded or is to remain isolated.

2–6. FOUR-TERMINAL OUTPUT

Four-terminal output should be used when the load is located some distance from the instrument or for low-resistance loads. The accuracy of the output voltage is maintained within specification at the load using the four-terminal connections with a maximum total resistance of 0.15 ohm in the sampling leads. For four-terminal positive output, connect the load as shown in Figure 2-3; for a negative output, connect the load as shown in Figure 2-4. If an isolated load is to be grounded using the metal terminal on the front panel, the terminal should be connected by a separate lead to the low side of the load. If a load is to remain isolated or is already grounded, omit the ground connection from the metal terminal.

Voltages between the metal terminal and GUARD terminal produce insignificant errors in the output voltage.

2–7. SERIES-CONNECTED INSTRUMENTS

Voltages up to twice the maximum output voltages of one 326 can be obtained by connecting two 326's as shown in Figures 2-5 and 2-6. Voltage between the positive terminals and GUARD terminal and voltage between GUARD terminal and ground will be limited to the maximum output voltage of one instrument.

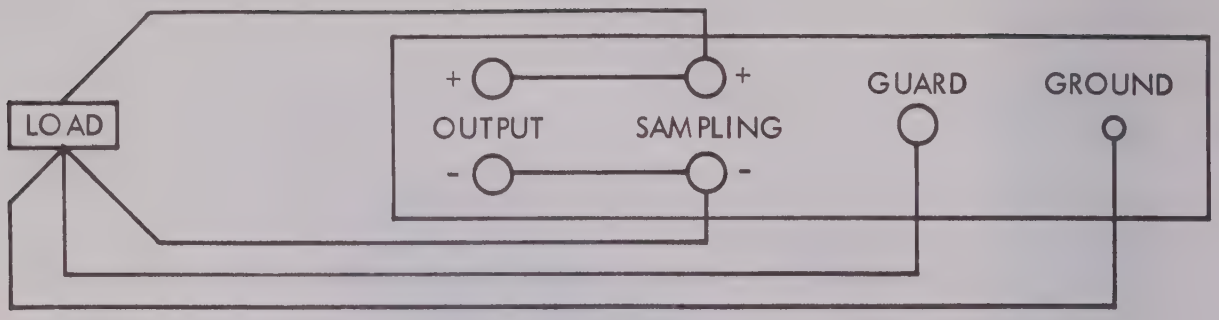


Figure 2-1. Two-Terminal Positive Output

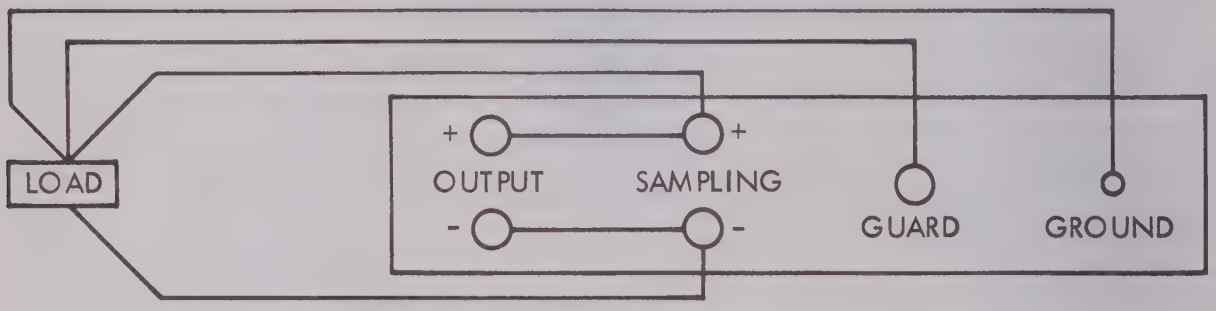


Figure 2-2. Two-Terminal Negative Output

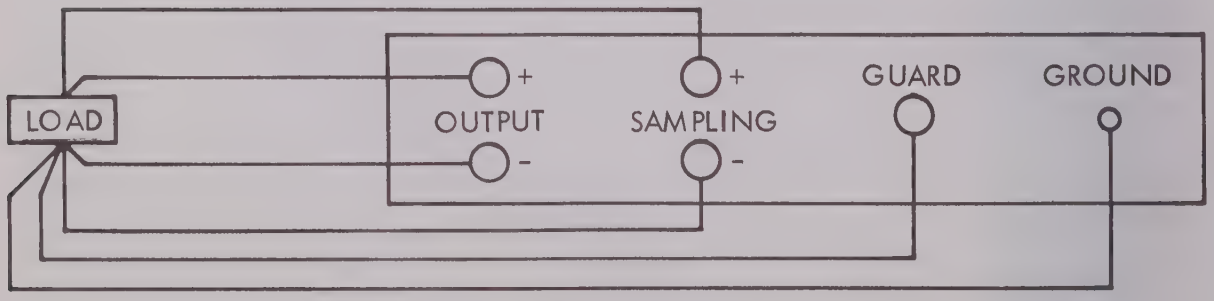


Figure 2-3. Four-Terminal Positive Output

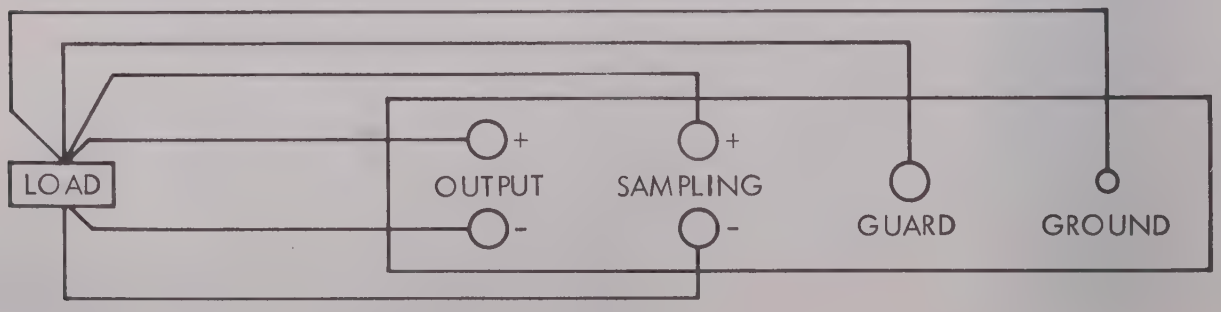


Figure 2-4. Four-Terminal Negative Output

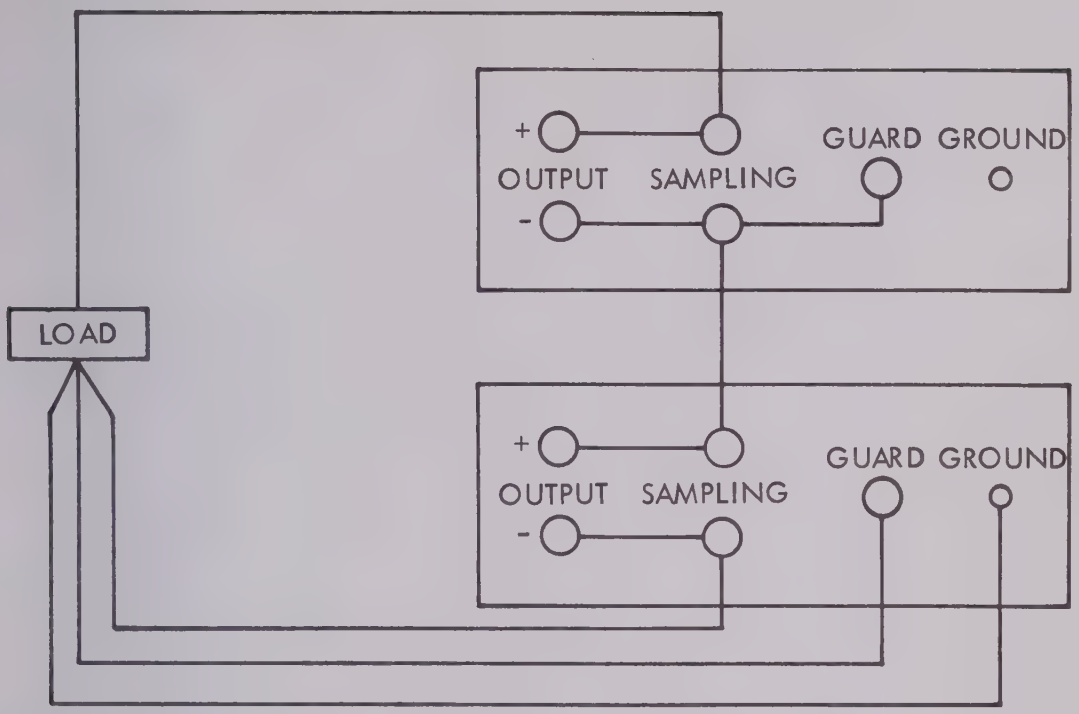


Figure 2-5. Two 326's Connected for Positive Output

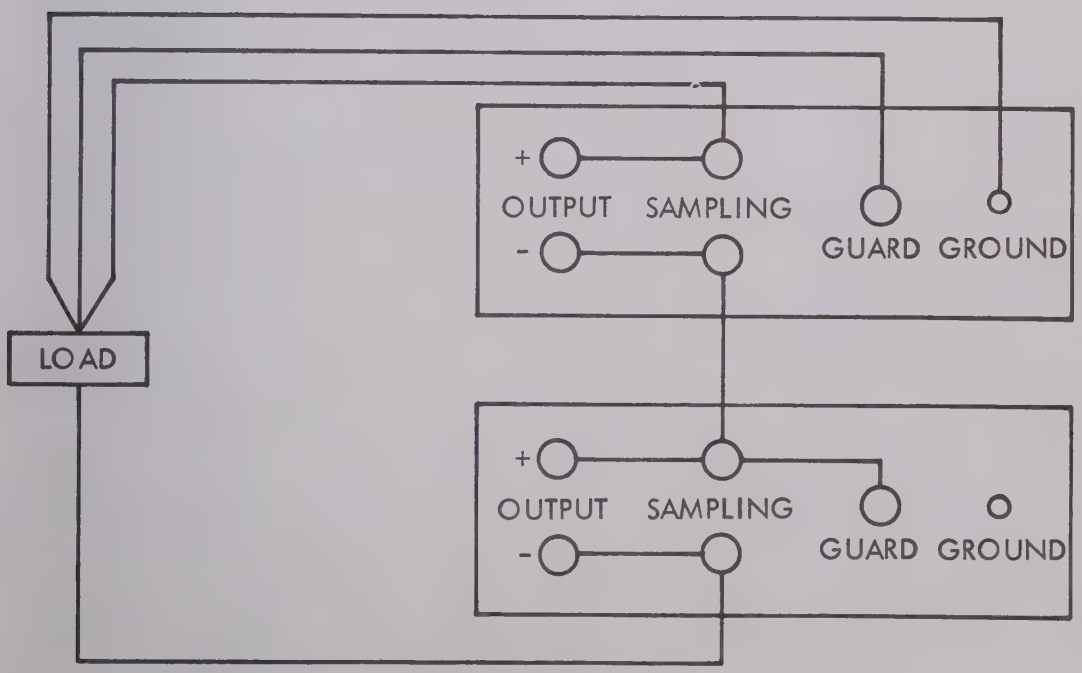


Figure 2-6. Two 326's Connected for Negative Output

2–8. REAR TERMINALS

If the instrument is equipped with terminals at the rear they should not be used simultaneously with the front-panel terminals. Connect the load to either the front-panel terminals or the rear terminals.

NOTE

Before making connections to either the front or rear terminals make sure that the other set of terminals is free of all connections.

2–9. OPERATING CONTROLS

The instrument's controls and their functions are as follows:

AC Switch and Indicator

When the switch is set to ON, ac power energizes the instrument and the AC indicator lights.

DC Switch and Indicator

When the switch is set to ON, the dialed voltage is available at the output terminals and the DC indicator lights. When the switch is set to OFF, the output voltage is reduced to zero and the indicator extinguishes.

VOLTAGE RANGE Switch and Indicators

The range switch is a three-position, detented switch that selects nominal full-scale ranges of 10 volts, 100 volts, and 1000 volts. One of three indicators, lights, showing decimal-point placement according to the range selected.

Decade Switches

Seven switches, used in conjunction with the VOLTAGE RANGE switch, set the level of output voltage.

CURRENT LIMIT Control

The setting of this control determines the operating point of the overcurrent protective circuit and indicates the maximum nominal current available over the range of 5 to 50 milliamperes.

OVER LOAD Switch and Indicator

This switch has three positions: AUTO, MANUAL, and RESET, with spring return to MANUAL from RESET.

When the switch is at MANUAL and an overcurrent or overvoltage condition occurs the protective circuit trips (indicator lights), and remains tripped until the condition is first removed and then the switch turned to RESET (indicator extinguishes).

When the switch is at AUTO and an overcurrent condition occurs, the protective circuit cycles (indicator flashes on and off) until the overcurrent is removed. The protective circuit then resets automatically (indicator extinguishes).

When the switch is at AUTO and an overvoltage condition occurs the protective circuit does not cycle, but trips (indicator lights) and remains tripped until the overvoltage is removed. The protective circuit then resets automatically.

NOTE

The AUTO mode of operation is designed to provide automatic resetting of the protective circuit whenever a momentary overload occurs. Therefore, it is recommended that the AUTO mode not be used if the possibility of steady state overload exists.

2–10. FUNCTIONAL CHECK

A functional check of the instrument may be made by using a meter capable of measuring 0.1 millivolt through 12 volts; a megohmmeter; a 100-ohm,

5% resistor; and an auxiliary dc supply. First, connect the positive OUTPUT terminal to the positive SAMPLING terminal and the negative OUTPUT terminal to the negative SAMPLING terminal, and then proceed as follows:

a. Preliminary

Before connecting the instrument to the ac-power outlet, check that the dc resistance is approximately 10^9 ohms between the following pairs of terminals:

positive SAMPLING and GUARD terminals
positive SAMPLING and ground terminals
GUARD and ground terminals

b. General Operation

1. Set, AC and DC switches to OFF, each decade dial to 0, OVER LOAD switch to MANUAL, CURRENT LIMIT control to 50 mA, and VOLTAGE RANGE switch to 10V.

2. Connect the instrument to the ac-power outlet and set AC switch to ON. The AC and OVER LOAD indicators and the left decimal point indicator should light, and the fan should operate.

3. Allow approximately one minute for stabilization.

4. Set OVER LOAD switch to RESET and let it return to MANUAL. The OVER LOAD indicator should extinguish. An approximately 20-second time delay is incorporated to prevent premature application of voltage to the output terminals. The indicator will not extinguish if the stabilization time allowed is insufficient; in this case, repeat the instruction in this step.

5. Connect the voltmeter to SAMPLING terminals.

6. Set DC switch to ON. The DC indicator should light.

7. Starting with the decade dial at the extreme left, turn the dial through its twelve positions (1-volt steps) and compare each setting with the voltage indicated by the voltmeter. Return the dial to 0.

8. Set VOLTAGE RANGE switch to 100V. The left decimal point indicator should extinguish and the center decimal point indicator should light.

9. Repeat the instructions in step 7 using the second dial from the left.

10. Set VOLTAGE RANGE switch to 1000V. The center decimal point indicator should extinguish and the right decimal point indicator should light.

11. Repeat the instructions in step 7 using the third dial from the left.

12. Repeat the instructions in step 7 using the fourth dial from the left (0.1-volt steps), then the fifth (10-millivolt steps), then the sixth (1-millivolt steps), and finally the dial at the extreme right (0.1-millivolt steps).

13. Set DC switch to OFF and disconnect the voltmeter.

c. Overcurrent Check

1. Set DC switch to OFF and connect the 100-ohm resistor across OUTPUT terminals.

2. Set VOLTAGE RANGE switch to 10V, CURRENT LIMIT control to 50 mA, and OVER LOAD switch to MANUAL.

3. Set the decade dials for 5.1-volt output and set DC switch to ON (this overloads the instrument by 1 milliampere). OVER LOAD indicator should light (protective circuit tripped).

4. Set OVER LOAD switch to RESET. The

1 of the same dial, and equal to the voltage indicated by position 1 of the same dial and position 1 of the next higher-decade dial. By using the X and XI positions, the same output voltage can be obtained with several different dial settings on each range; this permits the output voltage to be compared (using external indicating equipment) and provides a "self-checking" means for linearizing the instrument. Also, it may be more convenient in some cases to use the X and/or the XI positions when changing the level of output voltage. Use of the XI positions is mandatory to obtain the maximum output voltage on each range. To illustrate these features of the instrument some examples are given in Table 2-1.

Section III
CIRCUIT DESCRIPTION

3–1. GENERAL CIRCUIT DESCRIPTION

A simplified block diagram indicating the functional sections of the instrument is shown in Figure 3-1. The major functional section is the amplifier system. The amplifier system consists of a 60-hertz, suppressed carrier modulator; a carrier amplifier demodulator; an ac-coupled wideband amplifier; and a direct-coupled amplifier. The carrier amplifier is paralleled by the wideband amplifier, the combined outputs of which are applied to the dc amplifier. The dc amplifier drives the output tubes, which control the output voltage. Interstage coupling networks and internal feedback shape the response characteristics of the amplifier system to provide stability.

The amplifier characteristics are such that the accuracy of the output voltage is almost independent of all influences except the reference voltage and the ratio of the range resistors to the feedback-decade resistors. The reference-voltage circuit provides constant current for the range and feedback-decade resistance. The feedback-decade resistance consists of seven decades of precision resistors; the resistors are selected and connected in series when the decade switches are set for the desired output voltage. The range switch selects one of three precision resistors, the selected resistor determining the current in the feedback network. The voltage developed across the feedback network equals the output voltage of the instrument.

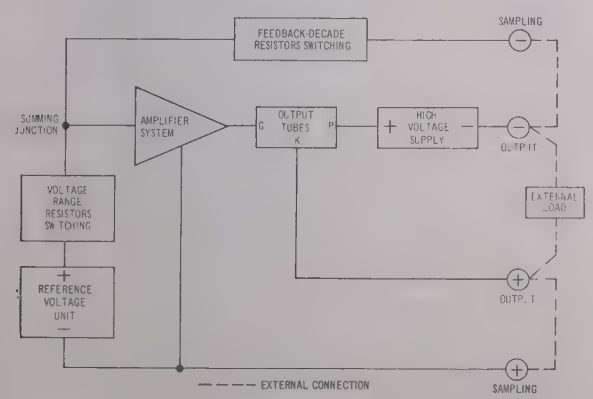


Figure 3-1. Simplified Block Diagram

The instrument is basically a low drift, wideband, high gain, negative feedback amplifier system. The feedback control is based on the network theorem that the algebraic sum of the currents at a junction equals zero, in this case, at the summing junction. In Figure 3-2, E_{in} is the reference voltage, R1 is the selected range resistor, R2 represents the selected feedback-decade resistors, A is the loop gain of the amplifier system, and E_{out} is the output voltage of the instrument. If the input current of the amplifier is negligible, all the current in R1 must flow through R2. The equation for the output voltage is:

$$E_{out} = -\frac{R2}{R1}\left[\frac{A\ \frac{R1}{R1+R2}}{1+A\ \frac{R1}{R1+R2}}\right] E_{in}$$

If $A\ \frac{R1}{R1+R2} \gg 1$ the term in the bracket is almost unity. Assuming that A is sufficiently large, the output voltage becomes simply $E_{out} = -\frac{R2}{R1} E_{in}$. The amplifier system has the required gain and the input characteristics necessary to make the assumptions involved in the approximate equation valid for output voltage from 0 to -1222.2221 volts. The output is isolated from the outer case and the ac-power lines so that output terminal inversion is possible to obtain output voltage from 0 to +1222.2221 volts.

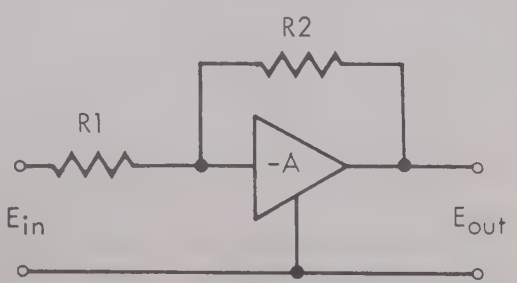


Figure 3-2. Feedback Amplifier

3–2. DETAILED CIRCUIT DESCRIPTION

In the following paragraphs of this section the circuits of the instrument are discussed in more detail with the aid of circuit diagrams.

3–3. POWER SUPPLIES

Power is supplied via a single transformer to the high-voltage power supply and the general power supply. The high-voltage power supply provides 1600 volts for the output tubes. The general power supply provides the following:

+380 volts for the dc amplifier

–380 volts for the dc amplifier

+320 volts for the carrier and wideband amplifiers

+240 volts for the carrier and wideband amplifiers

+170 volts for the screen grids of the output tubes

–47 volts for the protective circuit

+20 volts (approximately) time-delay pulse for the protective circuit

–22 volts for the control-grid bias circuit of V301, V303, and V304

+22 volts for the reference-voltage unit

+12 volts for the filaments of tubes V301 and V303 (6 volts each)

6.3 volts ac for the filaments of tubes V302 and V304

6.3 volts ac for the filaments of tubes V351 and V352

6.3 volts ac for the filaments of tubes V901 and V902 and for driving the chopper

650 volts ac for the demodulator

All dc voltages are referenced to circuit common except the 1600 and 170 volts. The –22 volts is dropped to –6 volts (on the amplifier board), which is divided to provide the control-grid bias for V301, V303, and V304, and is also applied to the zero-volt-output adjustment circuit.

Power for the front panel indicator lamps is derived from the +380-volt supply. This supply also provides approximately +120 volts for a time-delay circuit (DS1) on the general power supply board. The circuit provides a delay of approximately 20 seconds between the energization of the power transformer and the application of the time-delay pulse (approximately 20 volts) to the protective circuit.

3–4. REFERENCE-VOLTAGE UNIT

The reference-voltage unit consists of a constant-current preregulator in an electronically controlled oven. The oven is maintained at a temperature of 70^{+0}_{-5} degrees C and is stable to within 0.1 degree. The oven is powered by 15-volt and 40-volt windings on the power transformer. The reference-voltage circuit is powered by 22 volts dc from the general power supply. The output voltage of the reference circuit is approximately 6 volts dc.

3–5. VOLTAGE RANGE SWITCHING

The voltage-range circuit presents a constant load of 1.11 milliamperes to the output of the reference-voltage unit regardless of the setting of the VOLTAGE RANGE switch. This is illustrated in Figure 3-3 which shows that whichever range is selected, two of the three sets of range resistors are connected across the output of the reference-voltage unit and one set of resistors is connected in series with the reference-voltage unit to the summing junction when the DC switch is in the ON position. All three sets of resistors are connected across the reference-voltage unit when the DC switch is in the OFF position, thus removing the current to the summing junction. With no input current to the summing junction the output voltage of the instrument is zero.

3–6. FEEDBACK-DECADE NETWORK

The feedback-decade network has seven decades of resistance, and is the dc feedback circuit for the amplifier system. One of three sampling currents, as determined by the voltage-range switching circuit, flows in the feedback resistors. The current in the selected resistors is as follows: 10-volt range, 0.01 milliampere; 100-volt range, 0.1 milliampere; 1000-volt range, 1 milliampere.

The product of the sampling current and the selected feedback-decade resistors equals the voltage indicated by the range and decade dials. With the output voltage at the level indicated by the dials, the summing junction is virtually at zero potential with respect to circuit common (SAMPLING positive terminal). Any difference between the voltage developed across the selected resistors and the output voltage of the instrument appears as an error voltage at the summing junction. The error voltage, which is applied to the carrier and wideband amplifiers, is rapidly reduced to negligible proportions by the large loop gain of the amplifier system, and the output voltage is driven to the prescribed level.

3–7. CARRIER AMPLIFIER

The carrier amplifier circuit, Figure 3-4, consists of a chopper (contact modulator), G101, and three stages of amplification, V301B, V303, and V304.

The chopper is activated by 6.3 volts ac supplied by the power transformer. Chopper contacts 1 and 9 modulate the dc and the lower frequency components of the error voltage at the summing junction. The modulated signal, which has a rectangular-waveform of the same frequency as the ac voltage activating the chopper (power line frequency), is amplified by the three R-C coupled stages and applied to the demodulator.

A part of the V303 output is demodulated by chopper contacts 8 and 9, and is applied through a stabilizing circuit to the control-grid circuit of V302 in the wideband amplifier.

3–8. DEMODULATOR

The demodulator circuit and the dc balance circuit are shown in Figure 3-5. The demodulator

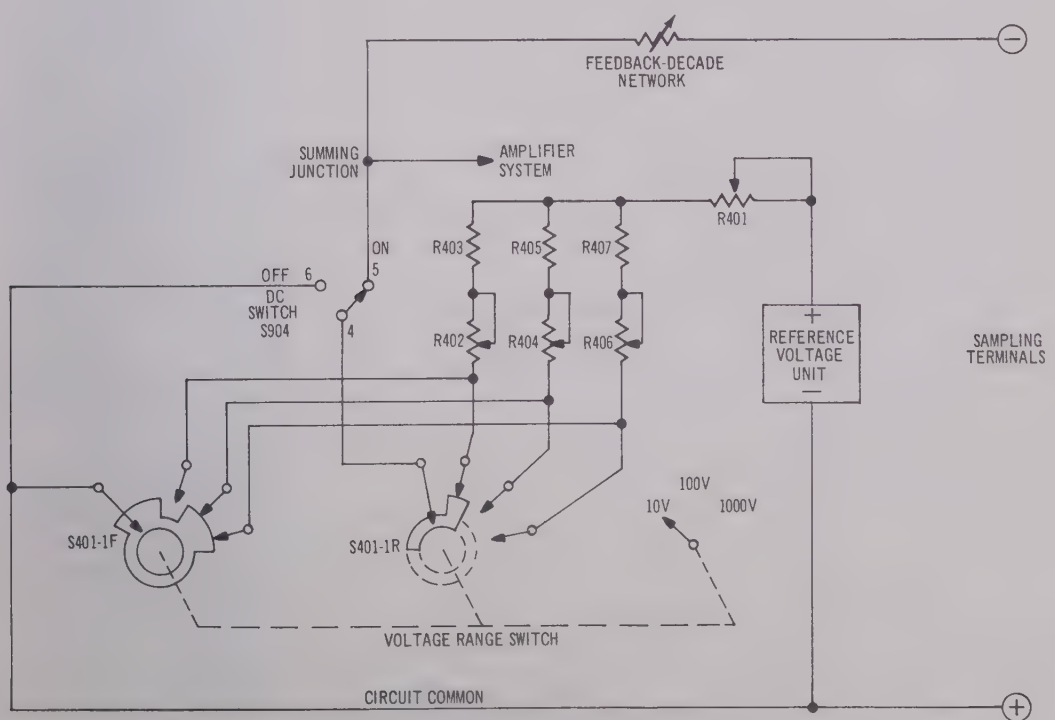


Figure 3-3. Voltage Range Switching Circuit

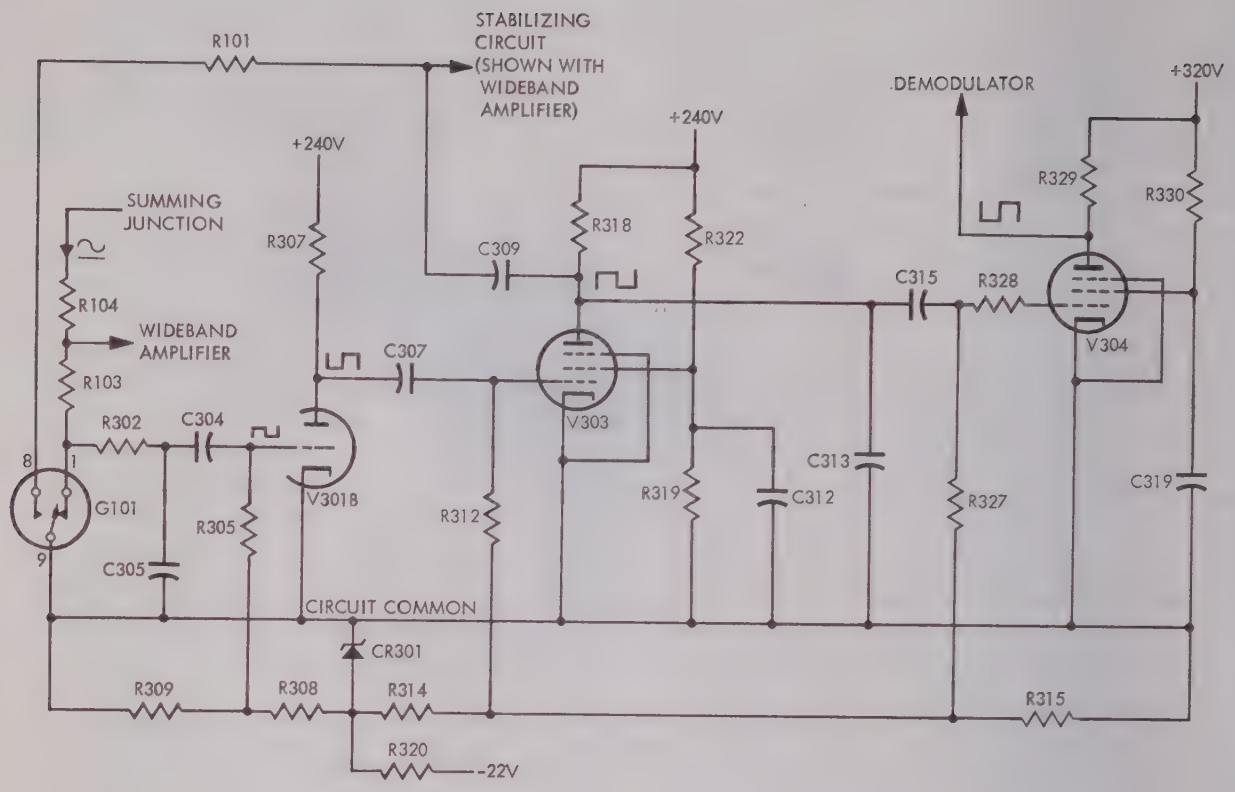


Figure 3-4. Carrier Amplifier Circuit

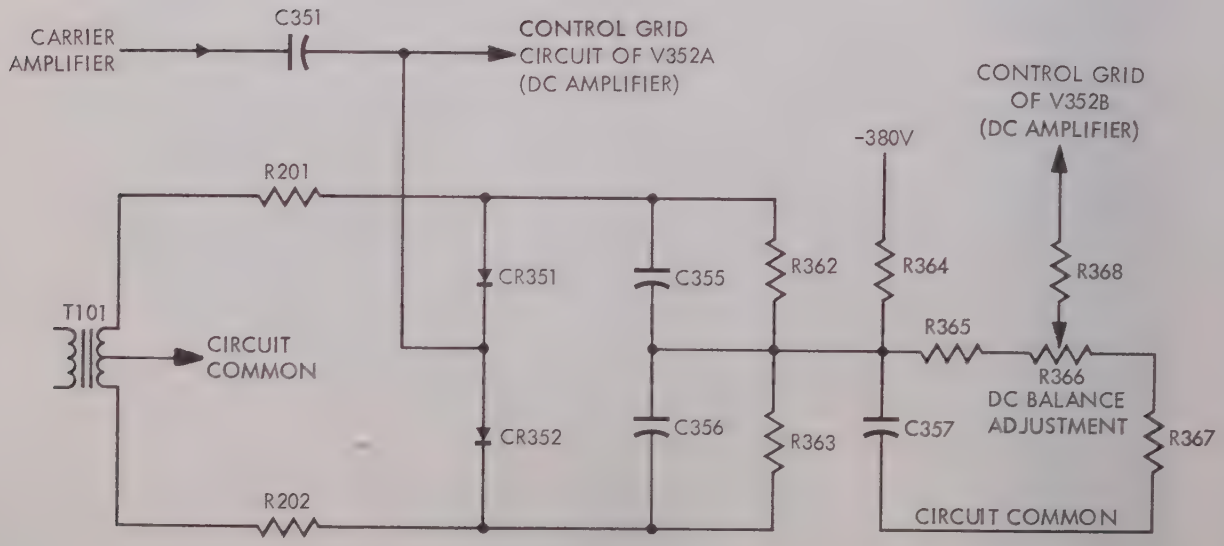


Figure 3-5. Demodulator and DC-Balance Circuits

consists of a bridge circuit which is driven by a 650-volt winding on the power transformer, T101. The drive voltage is properly phased for synchronous rectification of the rectangular-wave output of the carrier amplifier.

The output of the demodulator is of the same polarity and proportional to the dc and the lower frequency components of the error voltage at the summing junction. The demodulated error signal is combined with the higher frequency components from the wideband amplifier to provide a reconstituted signal, proportional to the summing junction error voltage, for driving the direct-coupled amplifier.

The demodulated error signal is clamped at a dc level determined by the –380-volt supply and the resistive network consisting of R364 and associated resistors. The setting of potentiometer R366 determines the level of bias voltage for the control grid of V352B in the direct-coupled amplifier.

3–9. WIDEBAND AMPLIFIER

The circuit of the wideband amplifier, Figure 3-6, consists of two amplifying stages (V301A and V302), overload compensation circuits, and a stabilizing circuit. The higher frequency components of the error voltage are amplified by the wideband amplifier, the output of which is applied to the direct-coupled amplifier.

The overload compensation circuits consist of C302 and R304 for V301A, and C310 and R321 for V302. A part of the demodulated output of V303 in the carrier amplifier is applied to V302 through the stabilizing circuit, R311, R313, and neon lamp DS301. During transient overload conditions, the increased output of V303 ionizes the neon lamp and thereby increases the current in the stabilizing circuit. The resulting increase in voltage across R317 reduces the time required for return to normal operation. Diode CR302 also aids the recovery of the wideband amplifier from overload.

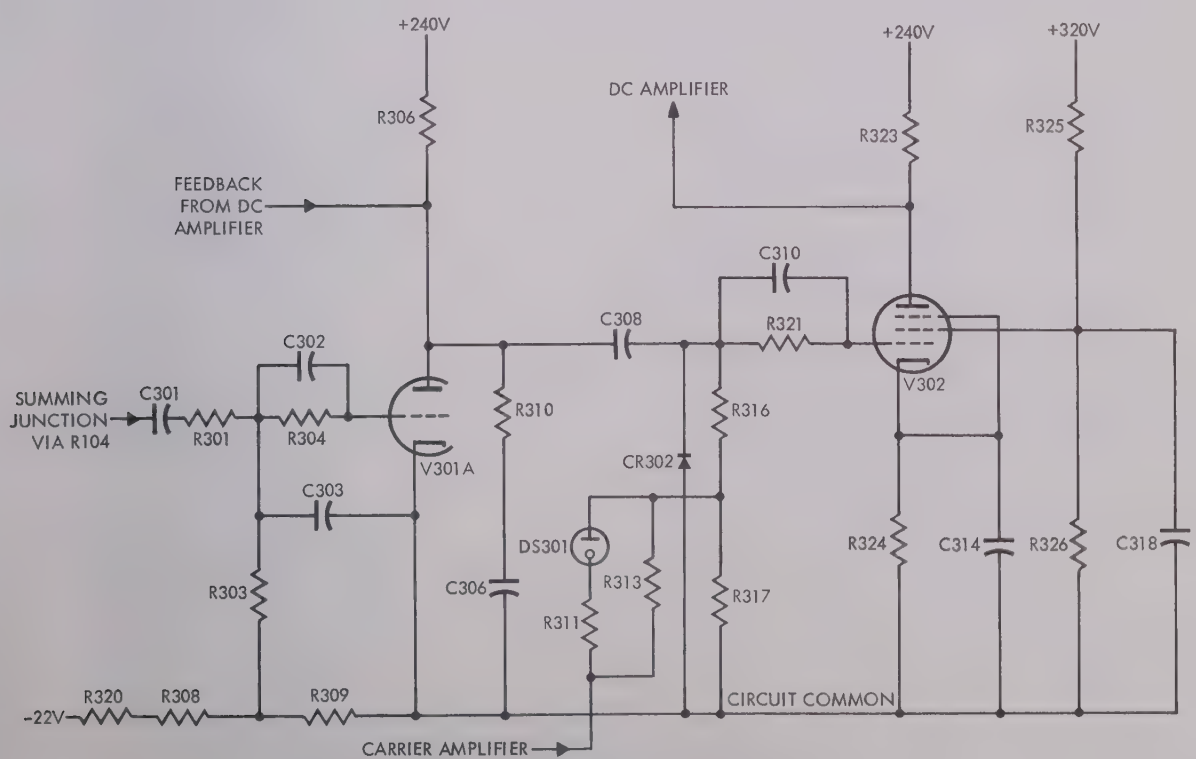


Figure 3-6. Wideband Amplifier Circuit

3–10. DIRECT-COUPLED AMPLIFIER

The circuit of the direct-coupled amplifier, Figure 3-7, consists of a cathode-coupled stage (V352A/V352B) and a cathode follower (V351). The outputs of the carrier and wideband amplifiers are applied to the direct-coupled amplifier, which drives the output tubes.

The demodulated output of the carrier amplifier is applied through R354 to the grid of V352A where it combines with the output of the wideband amplifier which is coupled by C352. Tube V352A is cathode coupled to V352B. The output of V352B is applied directly to the control grids of the output tubes.

The output of the wideband amplifier also is coupled to the control grid of V351. The output of V351 is applied through C359 to the control grids of the output tubes. Tube V351 passes the higher frequency components of the error voltage that are beyond the response of V352.

The pentode, V352B, drives the output tubes at dc and the medium frequencies of the error voltage; at these frequencies V352B provides large voltage gain with relatively large swing within a medium bandwidth. At the higher frequencies V351 provides a lower voltage swing capability but much lower output impedance; therefore, at frequencies above that at which the gain of V352B is unity the output tubes are driven by V351.

Feedback from the output of the direct-coupled amplifier, applied through C354 and R351, to the output of the first stage of the wideband amplifier stabilizes the transfer function of these stages.

3–11. OUTPUT TUBES

The circuits of the output tubes are shown in Figure 3-8, which also includes miscellaneous circuits not shown in other diagrams in this section. The output tubes are driven by the output of the direct-coupled amplifier.

The circuits of the output tubes include two voltages that are not referenced to circuit common; these are the 1600 volts applied to the plate by the high-voltage power supply and the 170 volts applied between the screen grid and the cathode

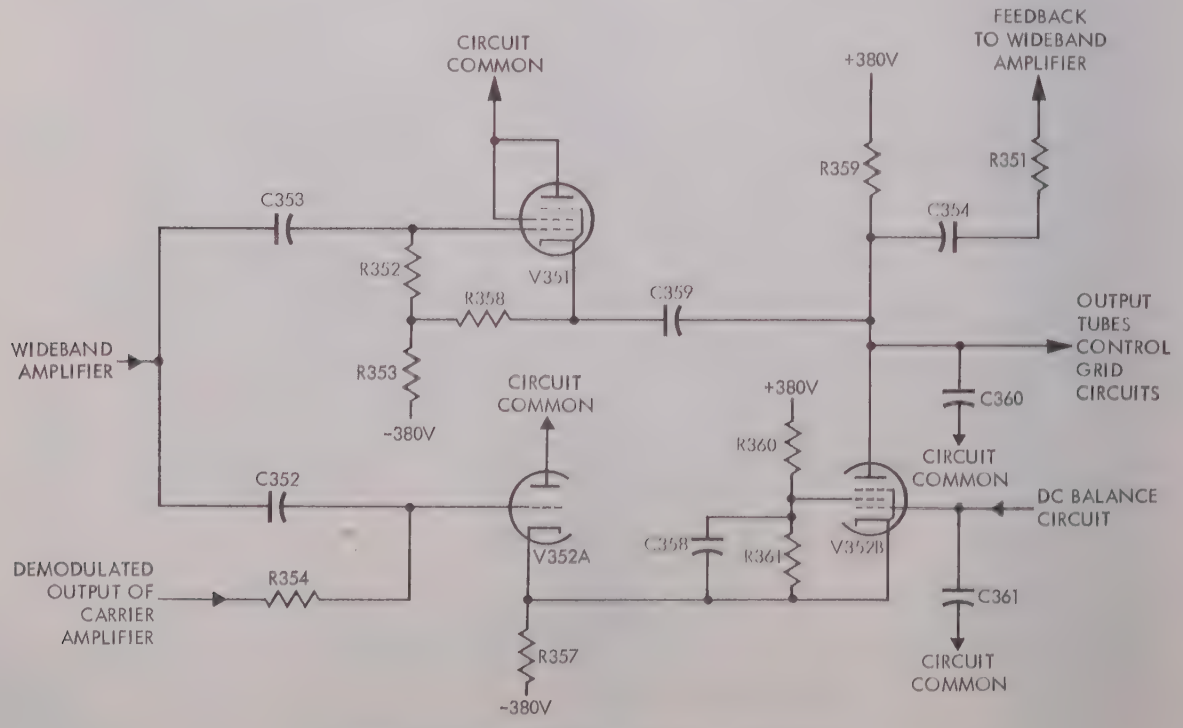


Figure 3-7. Direct-Coupled Amplifier Circuit

by the general power supply. The output tubes, V901 and V902, which are connected in parallel, are connected in series with the high-voltage power supply output (1600V), the output current-limit resistors shunted by C903, and the external load which is the plate load of the output tubes.

The load and the plate supply are transposed so that the output tubes function as voltage amplifiers rather than as cathode followers. The transposition is possible because the 1600-volt supply is not referenced to circuit common. This permits the positive SAMPLING terminal to be common to the amplifier system and the cathode circuit of the output tubes. This circuit arrangement reduces the voltage swing required of the direct-coupled amplifier to less than 100 volts rather than over 1000 volts.

3–12. MISCELLANEOUS CIRCUITS

Circuits not discussed elsewhere in this section are discussed in the following paragraphs and are shown in Figure 3-8.

Resistors R503, R504, and R505 permit a bleed current, from the +350-volt supply, to pass through the output tubes to prevent complete cut-off when the instrument is set for zero-volts output. Under normal operating conditions, the voltage developed across R503, R504, and R505 by the +350-volt supply is not present at the instrument's terminals. Diodes CR901 and CR902 prevent excessive voltage of the wrong polarity at the output terminals.

When the instrument is being used as a four-terminal source, R903 and R904, which parallel the external connections, minimize the shock hazard that would otherwise be increased should the positive or negative pair of leads be disconnected from each other at the load while the terminals of the instrument are energized.

Diodes CR101 and CR102 limit the error voltage to a level that will not overload or damage the chopper.

Capacitor C902 reduces the noise in the output of the instrument and influences the overall transfer function of the system. A discharge path for C902 is provided by R906.

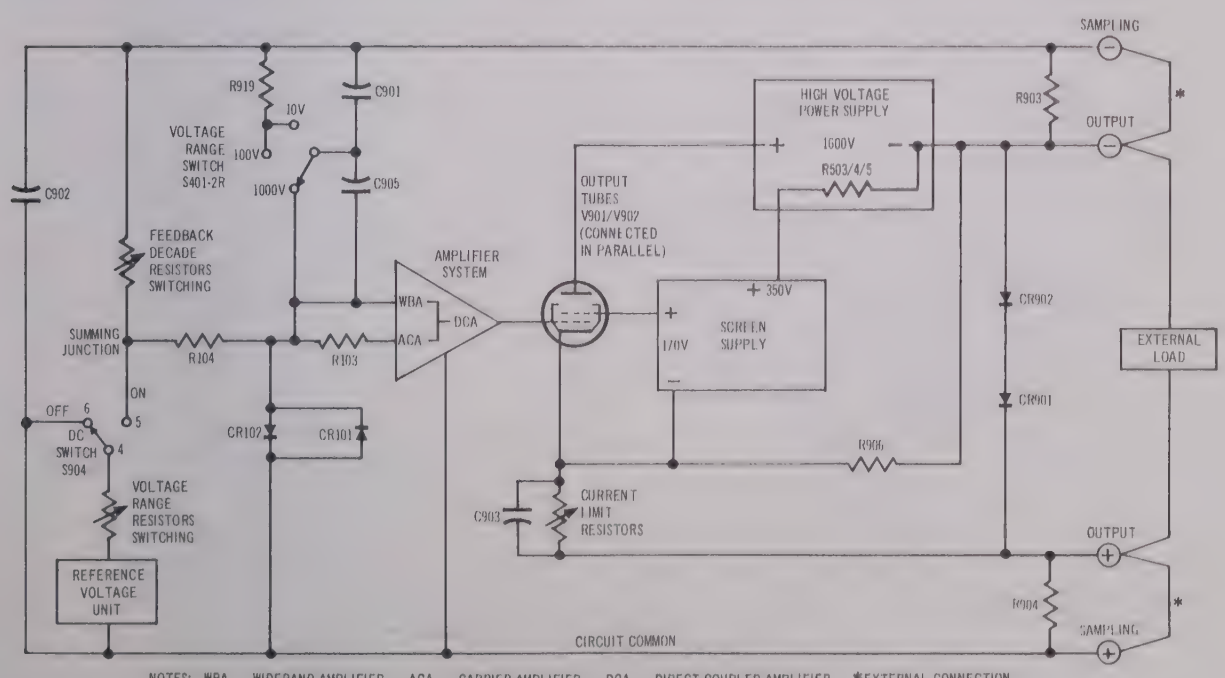


Figure 3-8. Output Tubes and Miscellaneous Circuits

High frequency feedback-signals bypass the feedback-decade network through C901 and C905. The decade network switch contacts are protected from the discharge of C901 and C905 by R104. A discharge path for C901 is provided by R919 when the VOLTAGE RANGE switch is at the 10V or 100V position, and C905 is discharged by short circuit when the switch is at the 1000V position.

When the DC switch is in the OFF position, no current from the reference-voltage unit flows to the summing junction and therefore the output voltage of the instrument is zero.

3–13. PROTECTIVE CIRCUIT

The protective circuit and its associated circuits, Figure 3-9, include overvoltage circuitry and overcurrent circuitry. These circuits protect the instrument and its load by reducing the output voltage to zero whenever there is an overvoltage condition at the load, the load current exceeds the limit to which the front panel CURRENT LIMIT control is set, or if an internal fault causes an overvoltage or overcurrent condition.

The protective circuit includes emitter followers Q801 and Q802, Schmitt trigger circuit Q803/Q806, silicon controlled switch (SCS) circuit Q804/Q805, and switch Q807. When the instrument is turned on only Q806 and Q807 conduct, the other transistors are in the cut-off state. After approximately 20 seconds, a positive pulse (approximately 20 volts) from the delay circuit on the power supply board turns on the SCS circuit. When the SCS circuit turns on it causes Q803 to switch on and Q806 to switch off, which is the normal state of the Schmitt trigger circuit. During the 20-second delay the negative voltage at the collector of Q807 lights the OVER LOAD indicator and cuts off the output tubes at the control grids until the amplifier system has warmed up sufficiently to control the output current. (Note that the SCS circuit remains on regardless of subsequent protective circuit operation.)

The hysteresis of the Schmitt trigger circuit is controlled by feedback capacitor C803. Transients in the protective circuit are suppressed by C804 and C806. Diodes CR804 and CR806 prevent voltage swings at the control grids of the output tubes from interfering with the operation of the protective circuit.

3–14. OVERVOLTAGE. The overvoltage circuitry operates if an overvoltage condition of approximately 10 percent occurs. When an overvoltage condition occurs, the error voltage appearing at the summing junction is amplified by the carrier amplifier. The positive excursion of the output of V303 in the carrier amplifier is sufficient to overcome the back bias of CR802 causing it to conduct. The resulting voltage at the base causes Q801 to conduct, which permits Q802 to conduct. When Q802 conducts, the Schmitt trigger circuit trips (Q803 switches off and Q806 switches on), which causes Q807 to switch on to drive the grids of the output tubes to cutoff. With the output tubes cut off the output voltage of the instrument is reduced to practically zero.

The protective circuit remains in this state until the overvoltage condition is removed. After the overvoltage condition is removed, if the OVER LOAD switch is in the MANUAL position, the circuit must be reset by turning the dial to the RESET position. If the switch is in the AUTO position the circuit resets automatically.

3–15. OVERCURRENT. Whenever the output current of the instrument exceeds the set limit, the protective circuit trips and remains tripped when the OVER LOAD switch is in the MANUAL position and cycles when the switch is in the AUTO position. While cycling, an average current, dependent on the external load is maintained low enough to prevent damage to the instrument.

The current level at which the protective circuit operates is determined by the setting of the front panel CURRENT LIMIT control, R901. The sensitivity of the circuit is determined by the amount of current by which the setting of the CURRENT LIMIT control is exceeded before the circuit operates, and is adjustable by R221.

If an overcurrent condition occurs, the increased current in the cathode circuits of the output tubes

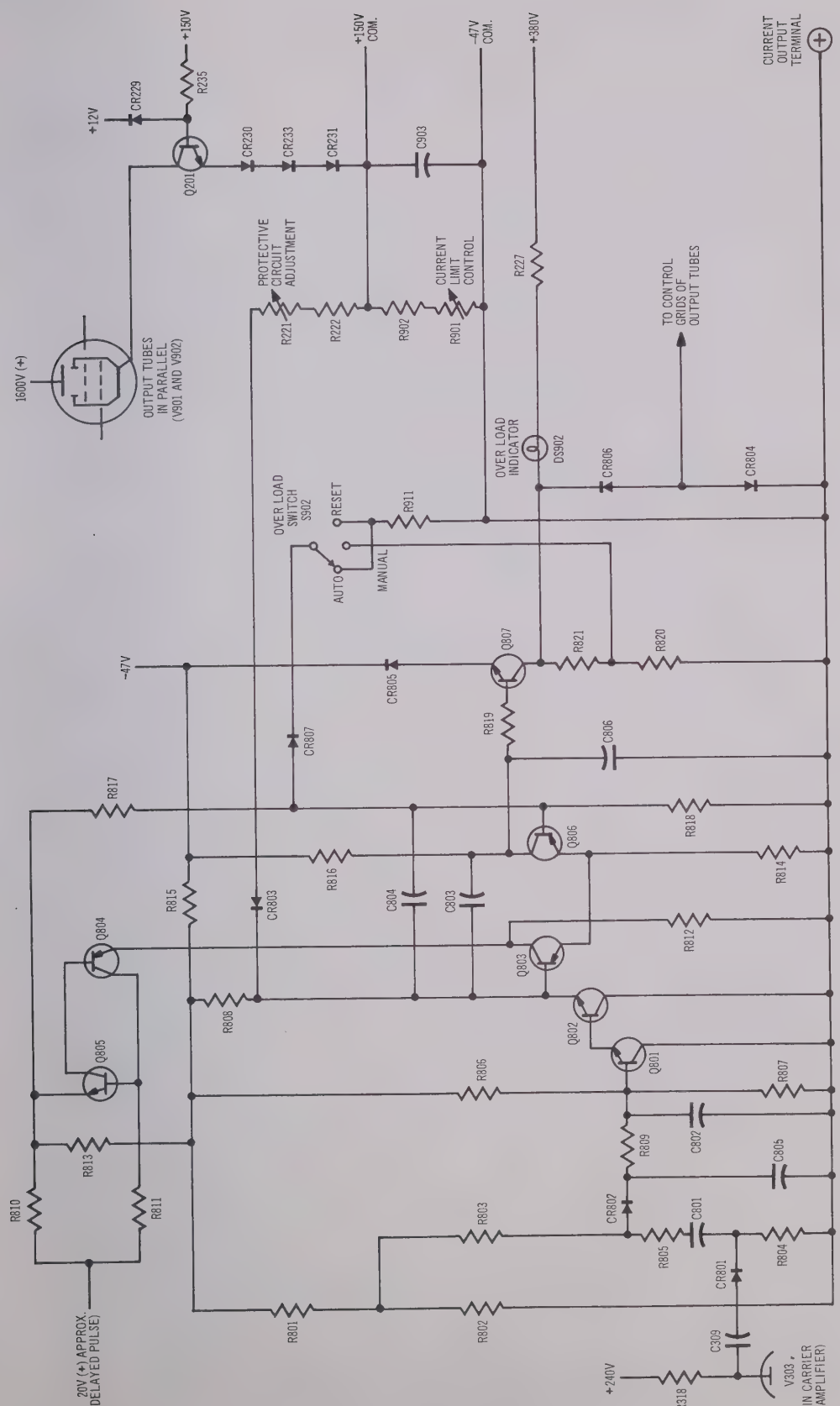


Figure 3-9. Protective Circuit

raises the voltage at the base of Q803 to a level that trips the Schmitt trigger circuit. This causes Q807 to switch on, which lights the OVER LOAD indicator, and cuts off the output tubes at the control grids thereby reducing the output to practically zero. (Note that Q801 and Q802 remain non-conducting when an overcurrent condition occurs.)

When the output is reduced to zero the overcurrent condition is removed from the instrument, and, if the OVER LOAD switch is in the AUTO position, the Schmitt trigger circuit, Q807, and the output voltage return to the normal state. If the overcurrent condition still exists or is reapplied to the instrument causing the protective circuit to trip, this sequence of operations continues until the overcurrent condition is removed or the switch is set to MANUAL.

When the OVER LOAD switch is set to MANUAL, or if it is in the MANUAL position when an overcurrent condition occurs, the negative voltage developed across R820 is applied to the Q806 base holding the Schmitt trigger circuit in the tripped state until the switch is set to RESET.

3–16. ELECTRONIC OUTPUT SWITCH. The output circuit of the instrument includes an electronic switch, Q201, connected as shown in Figure 3-9. When the instrument is operating, Q201 is in the switched-on state. The transistor is biased to the +12-volt filament supply through CR229 such that it very rapidly switches off and opens the output circuit at the instant that the instrument is turned off.

Section IV
MAINTENANCE

4–1. GENERAL

This section contains information and instructions for disassembly, parts location, preventive maintenance, troubleshooting, internal adjustments, and calibration. Maintenance support data includes the circuit descriptions in Section III, schematic diagrams, normal-operation voltages and waveforms, and a list of replacement parts.

4–2. DISASSEMBLY

WARNING

Do not attempt disassembly when the instrument is energized; if the outer cover plates are removed, shock hazard may exist unless certain precautions are taken (refer to paragraph 4-14).

The top and bottom plates of the outer cover can be removed after releasing six screws in the top and six screws in the bottom of the instrument. The removal of these plates reveals the chassis which has top and bottom cover plates each secured with eight screws. When the chassis plates are removed access to the circuit components is available. Only the top plate of the outer cover need be removed for recalibrating the instrument or adjusting the protective circuit.

4–3. PARTS LOCATION

The locations of the subassemblies and some of the components are indicated in Figures 4-1 through 4-4. A top view of the instrument is shown in Figure 4-1, a bottom view is shown in Figure 4-3, and Figures 4-2 and 4-4 show more clearly the locations of those components mounted on or immediately behind the front plate of the chassis. The etched-circuit boards are marked with the circuit reference designations of the components mounted on them.

4–4. PREVENTIVE MAINTENANCE

The instrument requires little routine maintenance other than keeping it clean. Inspect the interior periodically for cleanliness. Whenever it is cleaned internally, visually inspect the instrument for signs of deterioration.

4–5. GENERAL CLEANING

Clean the interior of the instrument at intervals determined by experience to minimize the accumulation of dust and lint. If available, compressed air is suitable for cleaning, otherwise use a soft-hair brush and a bench vacuum cleaner. However, if the former is used, take care not to cause damage by the use of excessive pressure. Cleaning of the front panel terminals should not be overlooked.

4–6. AIR FILTER

The filter element should be cleaned at intervals determined by environmental conditions. The filter is secured to the rear of the outer cover by four screws. Remove the filter and separate the element from its frame. Clean the element in warm soapy water and rinse thoroughly. After cleaning, the element may be recoated with any standard recoating compound, such as the RP Super Handikoter No. 411 (1 pint), No. 420 (1 gallon), or No. 421 (5 gallons) obtainable from Research Products Corporation, 1015 E. Washington Avenue, Madison 10, Wisconsin.

4–7. FAN MOTOR

The fan motor is a sealed unit requiring little maintenance and will give reliable performance from two to five years under usual conditions without the necessity of oiling. However, the life of the fan motor may be extended by periodic oilings. The oiling procedure requires the use of an oil injector which may be obtained from Rotron Manufacturing Company, Inc., Hasbrouck Lane,

Woodstock, New York. The oiling procedure is as follows:

a. Remove the top cover plate of the instrument.

b. Remove the air filter from the rear of the instrument.

c. Remove the four screws, washers, and nuts which fasten the fan to the outer case.

d. Raise the fan until the center hole in the insulator is accessible.

e. Remove the cap from the end of the oil injector.

f. Place needle of oil injector at the center of circle marked on the gold label.

g. Position the needle at an angle of approximately 45 degrees to the surface of the label and tangent to the perimeter of the circle.

h. Pierce the label and the concealed self-sealing rubber cap located under the label.

i. Insert the needle approximately 1/4 inch.

j. Depress the plunger of the oil injector slowly to allow approximately 1/16 inch of oil to escape. It is better to give a little more oil than not enough, however, do not overfill the well.

4–8. SWITCHES

Under normal operation the switches require no maintenance other than lubrication. Most maintenance methods are actually harmful and will shorten the life of a switch. Therefore, leave the switches alone unless maintenance due to adverse ambient conditions is absolutely necessary. In an excessively dusty or contaminated atmosphere occasional cleaning of the contacts may be beneficial. The contacts should be cleaned with a good degreasing solution such as carbon tetrachloride or methanol, allowed to dry, and then lightly lubricated with Oak No. 2008 grease or equivalent. It is recommended that the index assembly be lubricated after approximately every 1000 hours of operation.

4–9. CHOPPER

In addition to the fan motor the only other continuously moving part in the instrument is the chopper. Output noise and stability characteristics may be seriously degraded by a malfunctioning chopper. The most valid test of the chopper's performance is to replace it with one known to be good. However, more information on the nature and function of choppers is presented in COHU Service Notes, Code No. 13-57A, "Chopper Checkout Procedures for COHU Equipment."

4–10. PERFORMANCE CHECK

If the instrument is in frequent use a performance check is, of course, not necessary unless faulty operation is suspected. However, if it has not been used for a long time it would be worth while to test the instrument in accordance with the procedures in paragraph 2-10. The procedures check the performance of the instrument using output voltages up to 11 volts. As an additional check, the instrument performance may be checked at higher output voltages using appropriate test equipment.

4–11. CALIBRATION

Calibration is performed using a procedure consisting of four major steps. The instrument is first adjusted for zero-volt output on each voltage range, then the feedback-decade resistors are linearized followed by linearization of the voltage ranges, and finally the instrument is adjusted for absolute accuracy. Only one standard voltage is required for calibration and this is used when making the accuracy adjustment.

The linearization adjustments are made using a variable dc supply with comparable short term stability. Linearization of the feedback-decade resistors adjusts the ratio of the individual resistors in the three most significant decades start-

ing with the standard resistors in the fourth decade; this gives ratio errors of less than 0.0005 percent for the top three decades and the three voltage ranges. After the linearization, one final adjustment standardizes the instrument to a local voltage standard.

4–12. CALIBRATION EQUIPMENT

The following equipment is required for calibrating the instrument:

a. An auxiliary dc source of stable, variable voltage, such as another COHU dc voltage standard or other instrument of comparable stability.

b. A galvanometer with at least 10-microvolt full scale sensitivity, such as COHU Model 208R, 204A, 204AR, 203A, or 203AR or other instrument of comparable sensitivity.

c. A voltage standard, such as a certified standard cell.

d. A small, insulated screwdriver, or other tool suitable for adjusting trimming resistors.

4–13. CALIBRATION PROCEDURE

The instruments used for performing the calibration procedure should be operated in accordance with the instructions in their respective technical manuals. The calibration procedure should be performed at standard reference conditions (refer to paragraph 1-11), and is as follows:

a. Preliminary Procedure

1. Remove the top cover plate of the instrument.

2. Set each decade dial to 0.

3. Apply power to the instrument and the calibration equipment, and allow at least thirty minutes for stabilization.

4. Set CURRENT LIMIT control to 50 mA and OVER LOAD switch to AUTO.

b. Zero-Volt-Output Adjustment

1. Connect the instrument to the galvanometer as shown in Figure 4-5.

2. Disconnect the galvanometer leads at the terminals of the dc voltage standard and short the disconnected ends of the leads. Zero the galvanometer on the 10-microvolt range. Remove the short and reconnect the leads

3. Set VOLTAGE RANGE dial to 10V.

4. Adjust R916 to obtain a zero-volt indication on the galvanometer.

5. Set VOLTAGE RANGE switch to 100V.

6. Adjust R917 to obtain a zero-volt indication.

7. Set VOLTAGE RANGE switch to 1000V.

8. Adjust R918 to obtain a zero-volt indition.

9. Repeat steps 2 through 8 until no further adjustment is necessary.

c. Feedback-Decade-Resistors Linearity Adjustment

1. Connect the instrument to the calibration equipment as shown in Figure 4-6.

2. Disconnect the galvanometer leads at the terminals of the dc voltage standard and the auxiliary source, and short the disconnected ends of the leads. Zero the galvanometer on the 10-microvolt range. Remove the short and reconnect the leads.

3. Set the dials to 000.X000 and set the auxiliary source to 1 volt. Adjust the auxiliary source to obtain a null on the galvanometer. Set the dials to 001.0000 and adjust R441 to obtain the same null within the limits of ±3 microvolts.

4. Set the dials to 001.X000 and set the auxiliary source to 2 volts. Adjust the auxiliary source to obtain a null. Set the dials to 002.0000 and adjust R440 to obtain the same null within the limits of ±6 microvolts.

5. Set the dials to 003.X000 and set the auxiliary source to 4 volts. Adjust the auxiliary source to obtain a null. Set the dials to 004.0000 and adjust R443 to obtain the same null within the limits of ±12 microvolts. (Galvanometer on 30-microvolt range.)

6. Set the dials to 007.X000 and set the auxiliary source to 8 volts. Adjust the auxiliary source to obtain a null. Set the dials to 008.0000 and adjust R442 to obtain the same null within the limits of ±24 microvolts.

7. Set the dials to 00.X0000 and set the auxiliary source to 1 volt. Adjust the auxiliary source to obtain a null. Set the dials to 01.00000 and adjust R415 to obtain the same null within the limits of ±3 microvolts. (Galvanometer on 10-microvolt range.)

8. Set the dials to 01.X0000 and set the auxiliary source to 2 volts. Adjust the auxiliary source to obtain a null. Set the dials to 02.00000 and adjust R412 to obtain the same null within the limits of ±6 microvolts.

9. Set the dials to 03.X0000 and set the auxiliary source to 4 volts. Adjust the auxiliary source to obtain a null. Set the dials to 04.00000 and adjust R431 to obtain the same null within the limits of ±12 microvolts. (Galvanometer on 30-microvolt range.)

10. Set the dials to 07.X0000 and set the auxiliary source to 8 volts. Adjust the auxiliary source to obtain a null. Set the dials to 08.00000 and adjust R428 to obtain the same null within the limits of ±24 microvolts.

11. Set the dials to 0.X00000 and set the auxiliary source to 1 volt. Adjust the auxiliary source to obtain a null. Set the dials to 1.000000 and adjust R411 to obtain the same null within the limits of ±3 microvolts. (Galvanometer on 10-microvolt range.)

12. Set the dials to 1.X00000 and set the auxiliary source to 2 volts. Adjust the auxiliary source to obtain a null. Set the dials to 2.000000 and adjust R408 to obtain the same null within the limits of ±6 microvolts.

13. Set the dials to 3.X00000 and set the auxiliary source to 4 volts. Adjust the auxiliary source to obtain a null. Set the dials to 4.000000 and adjust R427 to obtain the same null within the limits of ±12 microvolts. (Galvanometer on 30-microvolt range.)

14. Set the dials to 7X.00000 and set the auxiliary source to 8 volts. Adjust the auxiliary source to obtain a null. Set the dials to 8.000000 and adjust R424 to obtain the same null within the limits of ±24 microvolts.

d. Voltage-Ranges Linearity Adjustment

1. The same setup is used to linearize the ranges as is used to linearize the feedback-decade resistors.

2. Disconnect the galvanometer leads at the terminals of the dc voltage standard and the auxiliary source, and short the disconnected ends of the leads. Zero the galvanometer on the 100-microvolt range. Remove the short and reconnect the leads.

3. Set the dials to 10.000000 (note, extreme left dial at 10) and set the auxiliary

source to 10 volts. Adjust the auxiliary source to obtain a null.

4. Set the dials to 0X.00000 and adjust R404 to obtain the same null as in step d.3 within the limits of ±30 microvolts.

5. Set the dials to 00X.0000 and adjust R406 to obtain the same null as in step d.3 within the limits of ±30 microvolts.

6. Set the dials to 10.000000 (same setting as in d.3) and adjust R402 to obtain the same null as in step d.3 within the limits of ±30 microvolts.

7. Repeat steps 4 through 6 until no further adjustment is needed.

e. Accuracy Adjustment

1. Set the dials to indicate the voltage of the local voltage standard.

2. Connect the instrument to the galvanometer and the voltage standard as shown in Figure 4-7.

3. Disconnect the galvanometer leads at the terminals of the voltage standards, and short the disconnected ends of the leads. Zero the galvanometer on the 10-microvolt range. Remove the short and reconnect the leads.

4. Adjust R401 to obtain a null.

4–14. TROUBLESHOOTING

WARNING

To minimize shock hazard when troubleshooting with the instrument energized, connect SAMPLING positive and GUARD terminals to the metal terminal (ground). This provides a negative output and ensures that the selected output voltage is not present between the chassis and conduit ground.

Familiarity with the operation and the circuits of the instrument is advisable before troubleshooting is attempted. Knowing how the instrument functions, the general area within which a fault exists sometimes can be determined simply by operating the controls and noting the results. Try this as a first step and attempt to locate the fault by checking for overheated components, discolored resistors, broken wires, cold electron tubes, etc. If this method fails to give some indication of the trouble a systematic check of the circuits may be necessary.

4–15. LOCALIZING TROUBLE

Before making a complete systematic check of the instrument circuits it would be advisable to investigate the protective circuit first. The protective circuit is of necessity sensitive and could be tripped by any one of a number of faults, including faults within the protective circuit itself. When the protective circuit operates, the OVER LOAD indicator lights or flashes on and off, in which case attempt to reset the protective circuit.

If it is impossible to reset the protective circuit, check for an external overload condition by removing the load. If this is not the cause of the trouble the next step is to determine whether an abnormal condition elsewhere is tripping the protective circuit or whether the protective circuit itself is faulty.

To determine whether the protective circuit is giving trouble, proceed as follows: set the instrument for an output of at least 100 volts, remove any error voltage that may exist at the summing junction by momentarily shorting terminal 72 (see Figure 4-8 for location) on the amplifier board to circuit common, and then with terminal 72 shorted attempt to reset the protective circuit.

CAUTION

Never short terminal 72 to circuit common for more than a very few seconds as this unbalances the internal loop, and the output tubes V901 and V902, conduct excessively.

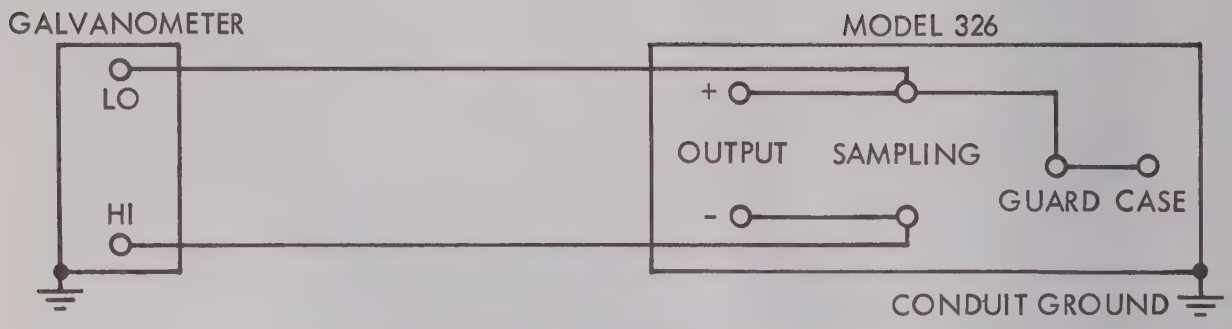


Figure 4-5. Zero-Volt-Output-Adjustment Calibration Setup

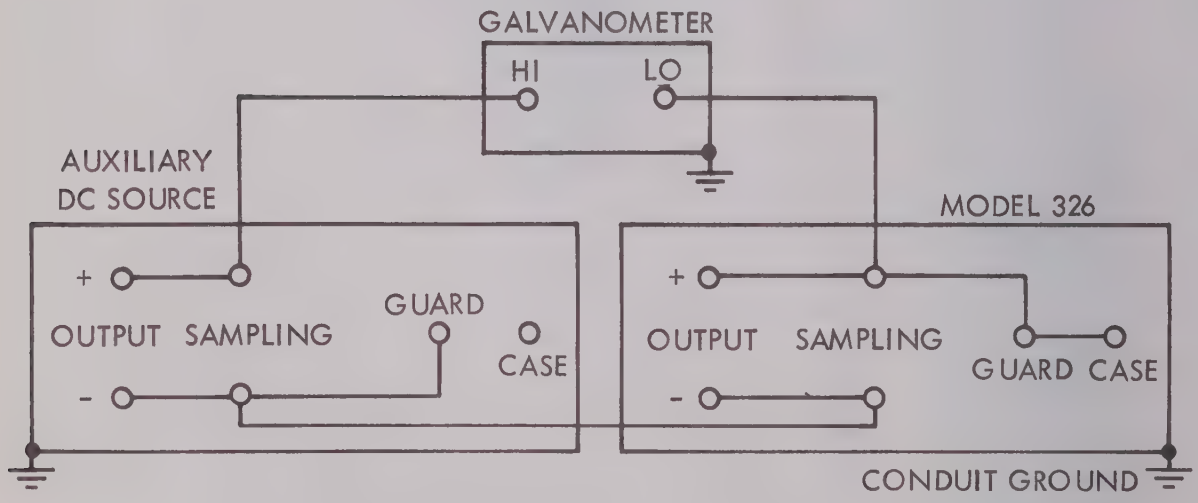


Figure 4-6. Linearity-Adjustment Calibration Setup

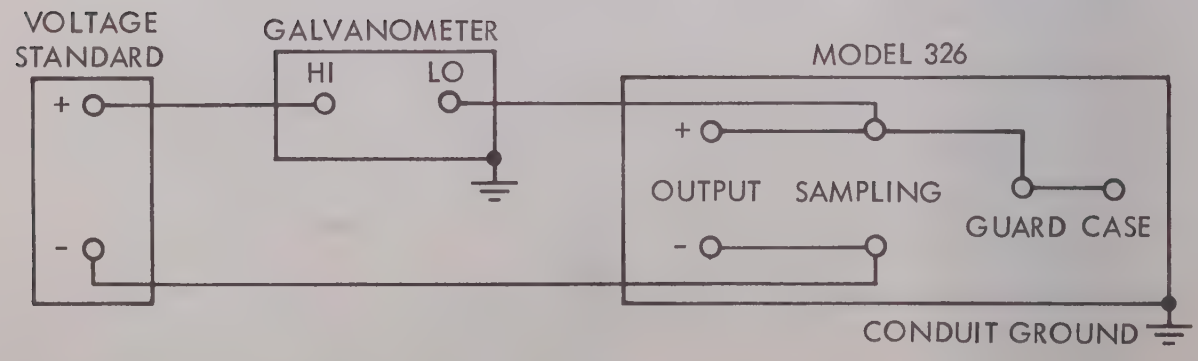
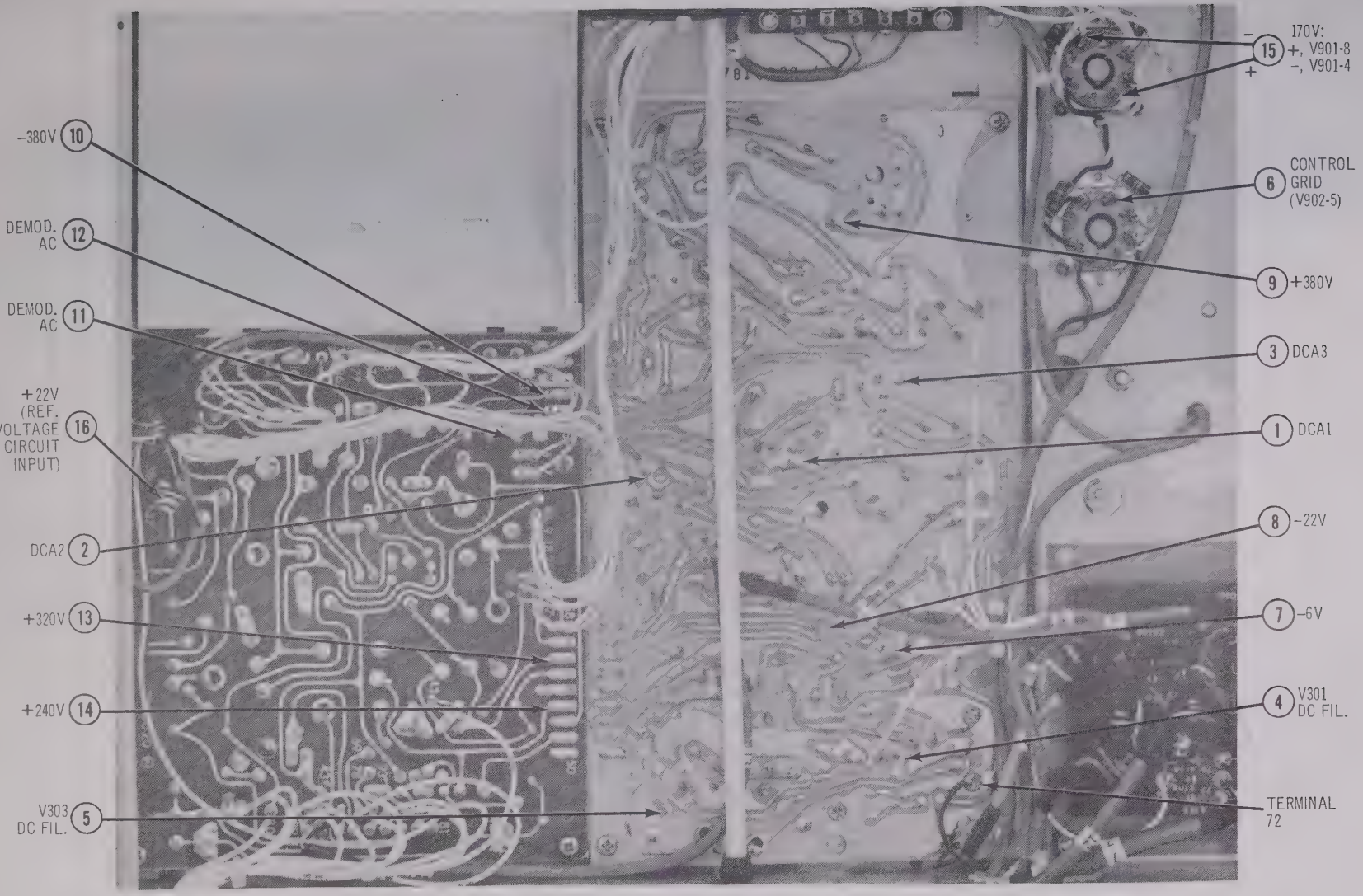


Figure 4-7. Accuracy-Adjustment Calibration Setup



NOTE: ALL WAVEFORMS AND VOLTAGES ARE REFERENCED TO CIRCUIT COMMON EXCEPT 170V

Figure 4-8. Major Checkpoint Locations

If this causes the OVER LOAD indicator to extinguish, the protective circuit and the carrier amplifier, except the output stage (V304), may be presumed to be functioning properly.

If the indicator does not extinguish, either the protective circuit or the carrier amplifier or both may be faulty. In this case, check the voltage at the junction of R803 and R805 on the protective circuit board; this voltage should be approximately –8.2 volts. If the voltage is correct it can be presumed that the carrier amplifier, except the output stage (V304), is functioning properly and that a faulty condition within the protective circuit is preventing Q807 from switching off.

If the protective circuit can be reset (OVER LOAD indicator extinguishes) with terminal 72 momentarily shorted to circuit common, this could mean an error signal at the summing junction due to the dc amplifier not responding to the correcting voltage. In this case, measure the ac correcting voltage at the point DCA2 on the amplifier board; this voltage is normally less than 10 volts peak-to-peak. (See Figure 4-8 for checkpoint location.) Also, compare the waveform shown in Figure 4-9.

If the correcting voltage is high it is possible that the dc amplifier is faulty, otherwise the output tubes, V901 and V902, their supply voltages, and closely associated circuits should be checked. If the correcting voltage is low or absent check the output stage, V304, of the carrier amplifier.

If the protective circuit is functioning properly and there is no output from the instrument when the protective circuit is reset, the cause may be due to a defective output tube, loss of voltage at the output tubes, open output tube cathode circuit, loss of reference voltage, or an open range resistor.

Any fault not located by association with the protective circuit can be localized with the aid of the main schematic diagram, Figure 4-17. Make a systematic check of the voltages shown on this diagram and the individual circuit board schematic diagrams Figures 4-12 through 4-16, and trace signals to localize the fault to a particular area. The waveforms shown in Figures 4-9 and 4-10 appear at the points indicated by circled numbers in Figure 4-8 and show normal no-load conditions. These points are also indicated by the same circled numbers on the amplifier schematic diagram and on the main schematic diagram.

4–16. LOCATING FAULTS

When trouble has been localized to a particular area, such as a circuit board or stage, locate the fault by employing the usual troubleshooting methods of tracing signals, checking waveforms, measuring voltages, and testing components; no special techniques are required. Systematically check the circuits of the suspected area with the aid of the appropriate schematic diagram. The schematic diagrams are marked with normal operating voltages under no-load conditions and were measured using a meter having a 100-megohm input. The voltages marked on the protective circuit diagram are for the protective circuit in the normal state and the tripped state.

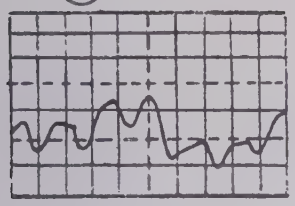
4–17. INTERNAL ADJUSTMENTS

Adjustments can be made to the dc balance circuit and the protective circuit. The dc-balance adjustment, R366, sets the level of bias voltage for the control grid of V352B in the dc amplifier. The protective-circuit adjustment, R221, sets the level of bias voltage for the base of Q803, which is part of the Schmitt trigger circuit, and determines the level of operation of the protective circuit.

4–18. PROTECTIVE-CIRCUIT ADJUSTMENT

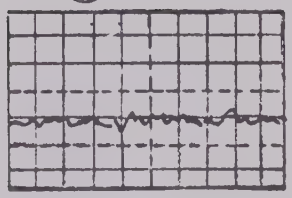
The protective circuit bias voltage should be adjusted if the level of operation of the protective circuit is too high or too low, or after repairing the protective circuit. The procedure, which

(1) DCA1



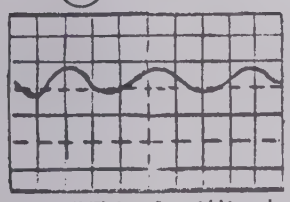
SENSITIVITY: 50 millivolts/cm

(2) DCA2



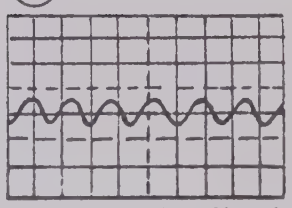
SENSITIVITY: 10 volts/cm

(3) DCA3



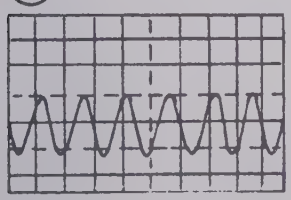
SENSITIVITY: 1 millivolt/cm

(4) V301 DC FIL.



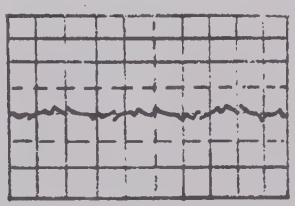
SENSITIVITY: 50 millivolts/cm

(5) V303 DC FIL.



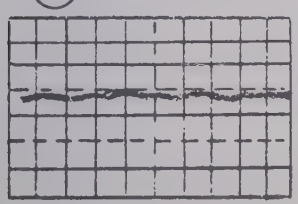
SENSITIVITY: 500 millivolts/cm

(6) V902 CONTROL GRID



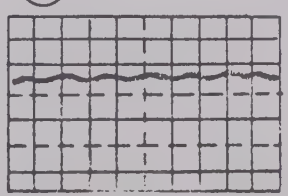
SENSITIVITY: 50 millivolts/cm

(7) -6 VOLTS



SENSITIVITY: 200 microvolts/cm

(8) -22 VOLTS



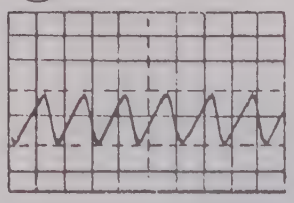
SENSITIVITY: 200 microvolts/cm

NOTES

1. The sweep for all waveforms is 5 milliseconds/centimeter
2. (1) thru (8) indicate waveform check points in Figures 4-8, 4-14, and 4-17.

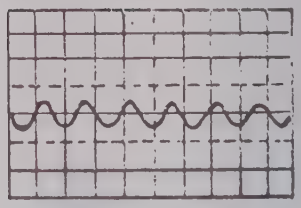
Figure 4-9. Waveforms (1) Through (10)

(9) +380 VOLTS



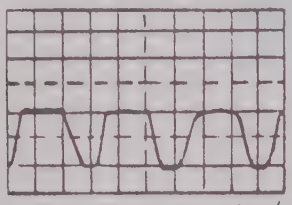
SENSITIVITY: 5 volts/cm

(10) -380 VOLTS



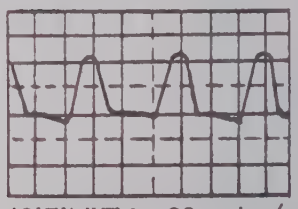
SENSITIVITY: 100 millivolts/cm

(11) DEMOD. AC (A301-59)



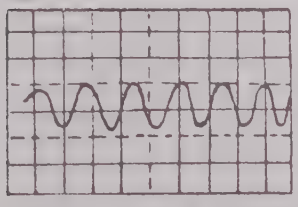
SENSITIVITY: 20 volts/cm

(12) DEMOD. AC (A301-60)



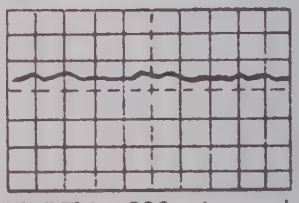
SENSITIVITY: 20 volts/cm

(13) +320 VOLTS



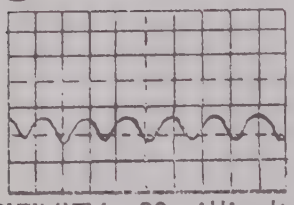
SENSITIVITY: 10 millivolts/cm

(14) +240 VOLTS



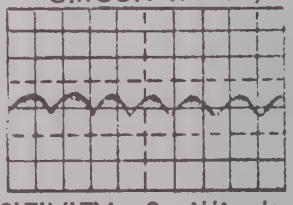
SENSITIVITY: 200 microvolts/cm

(15) +170 VOLTS



SENSITIVITY: 20 millivolts/cm

(16) +22 VOLTS (REFERENCE VOLTAGE CIRCUIT INPUT)



SENSITIVITY: 2 millivolts/cm

NOTES

1. The sweep for all waveforms is 5 milliseconds/centimeter
2. (9) thru (16) indicate waveform check points in Figures 4-8, 4-14, and 4-17.

Figure 4-10. Waveforms (11) Through (16)

requires the use of a 100-ohm, 5-percent resistor, is as follows:

a. Set DC switch to OFF.

b. Set OVER LOAD switch to MANUAL.

c. Set CURRENT LIMIT control to 50 mA.

d. Set VOLTAGE RANGE switch to 10V.

e. Connect the 100-ohm resistor across OUTPUT terminals and set the dials for 5.1 volts. (This represents a load of 51 milliamperes.)

f. Turn R221 (see Figure 4-11 for location) fully clockwise.

g. Set DC switch to ON. DC indicator should light and OVER LOAD indicator should not light.

h. Slowly turn R221 counterclockwise until OVER LOAD indicator lights. (Do not turn R221 beyond this point.)

The protective circuit is now adjusted to function when the load current is at least 1 milliampere above the limit to which the CURRENT LIMIT control is set. If it is desired to raise the level of operation of the protective circuit, R221 should be adjusted with the dials set for an output voltage higher than 5.1 volts at step f. (Each 0.1 volt higher raises the level of operation 1 milliampere.) Check the level of operation of the protective circuit using procedures c and d in paragraph 2-10.

4–19. DC-BALANCE ADJUSTMENT

Whenever the carrier amplifier or the dc amplifier has been repaired, the dc-balance circuit should be adjusted as follows using an oscilloscope with an input resistance of 10 megohms or greater:

a. Connect the oscilloscope between point DCA2 (see Figure 4-8 for location) and circuit common (SAMPLING positive terminal).

b. Set the oscilloscope for 10-volts-per-centimeter sensitivity and 5-milliseconds-per-centimeter time base.

c. Adjust R366 (see Figure 4-11 for location) to obtain a minimum signal. The peak-to-peak voltage of the signal should be approximately 10 volts. Compare the waveform observed with the DCA2 waveform shown in Figure 4-9.

4–20. CORRECTIVE MAINTENANCE

When troubleshooting or performing corrective maintenance the following points should be borne in mind:

a. It is recommended that no attempt be made to troubleshoot the reference voltage unit. If it gives trouble it should be replaced because special testing is necessary to correct a faulty unit.

b. The chopper is of the plug-in type and easily replaceable. The most valid performance test of a chopper is to replace it with one known to be good. Do not replace the chopper with the instrument turned on.

c. If troubleshooting indicates that a circuit board is faulty, and a tube is not the cause, replacing the board with a spare may be the quickest way to restore the instrument to service.

d. After repair of the protective circuit R221 may require readjustment (refer to paragraph 4-18).

e. If the carrier amplifier or the dc amplifier is repaired R366 may require readjustment (refer to paragraph 4-19).

f. Observe the usual precautions when handling or soldering the printed circuit boards.

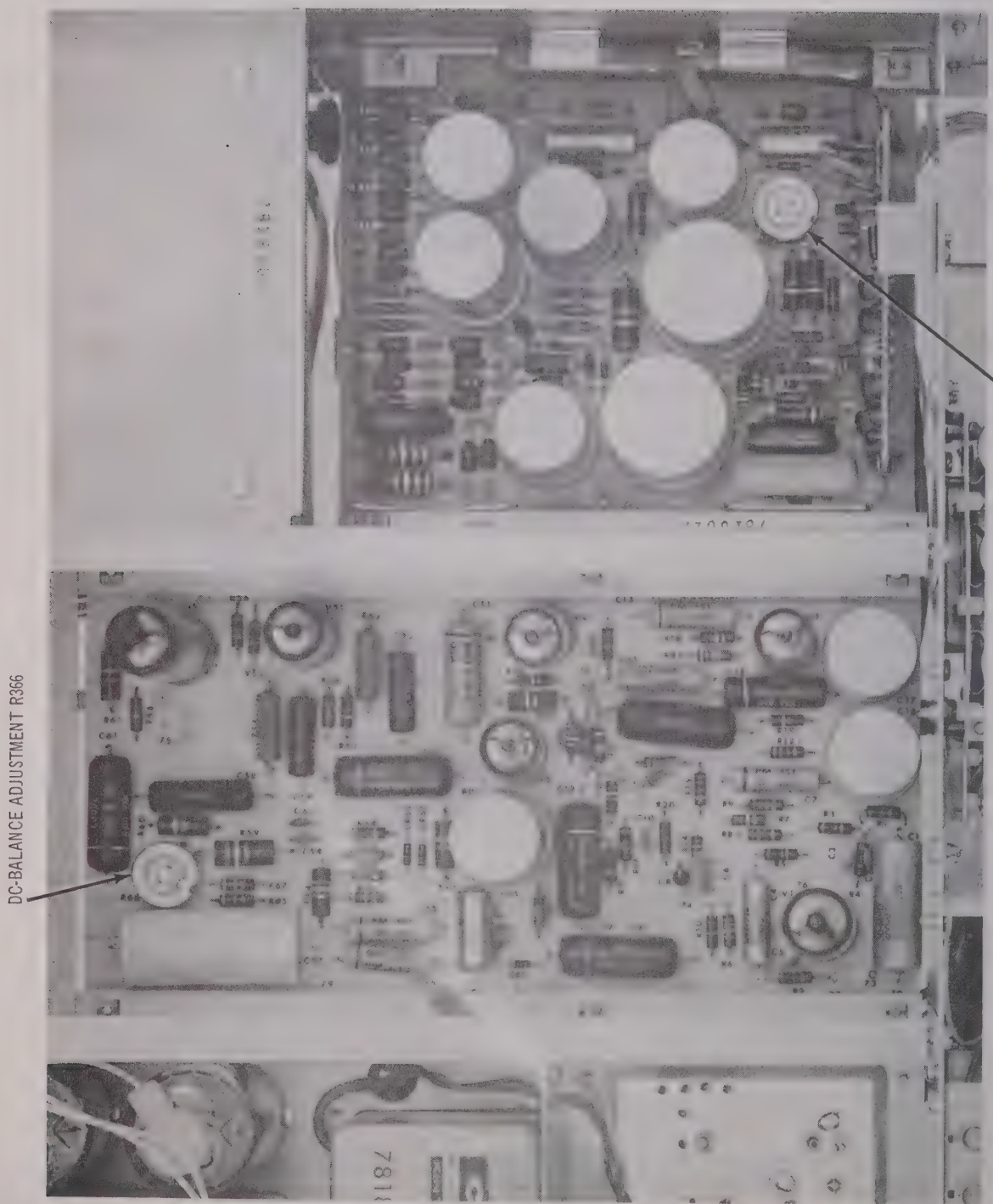


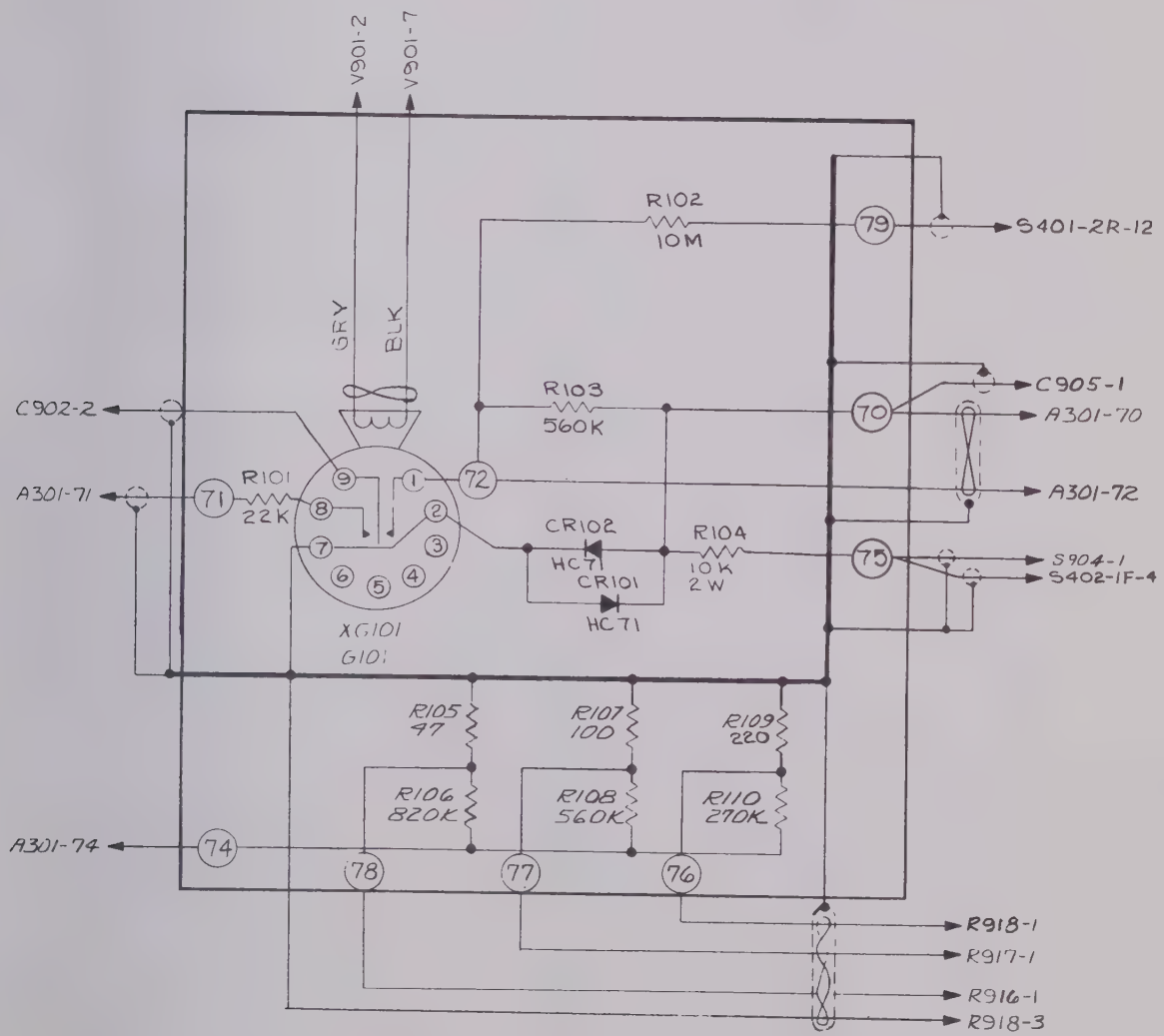
Figure 4-11. Protective and DC-Balance Circuits Adjustment Locations

4–21. REPLACEMENT PARTS

A list of replacement parts, arranged alphanumerically according to circuit reference designation, is contained in Table 4-1.

NOTE

If the type, value, etc., of a component to be replaced is different from that given in Table 4-1, make the replacement using the component listed in the table.



NOTES: 1. RESISTOR VALUES IN OHMS, ½ W.
UNLESS OTHERWISE SPECIFIED

Figure 4-12. Chopper Board Schematic Diagram (Drawing No. C7820027A)

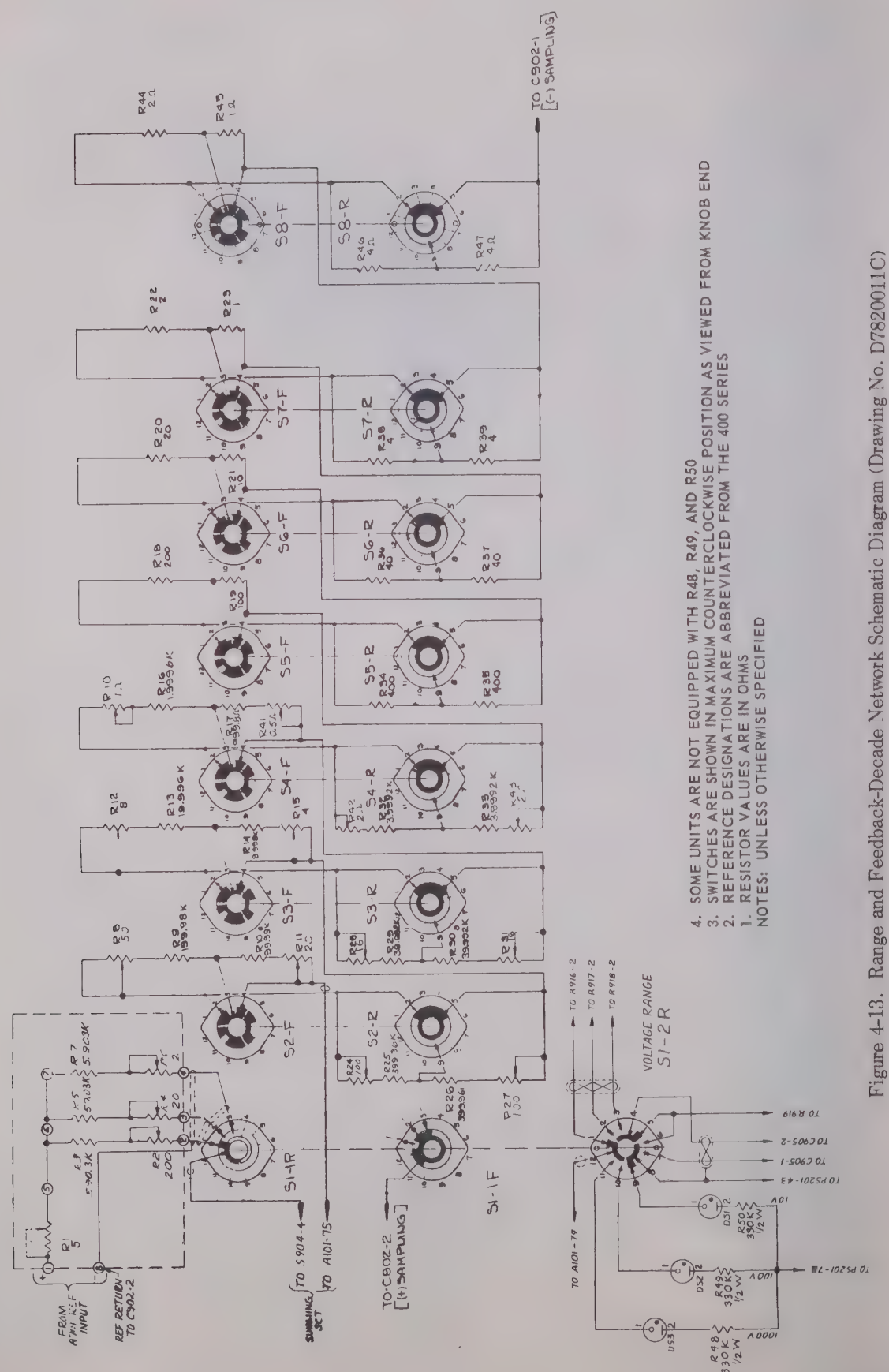
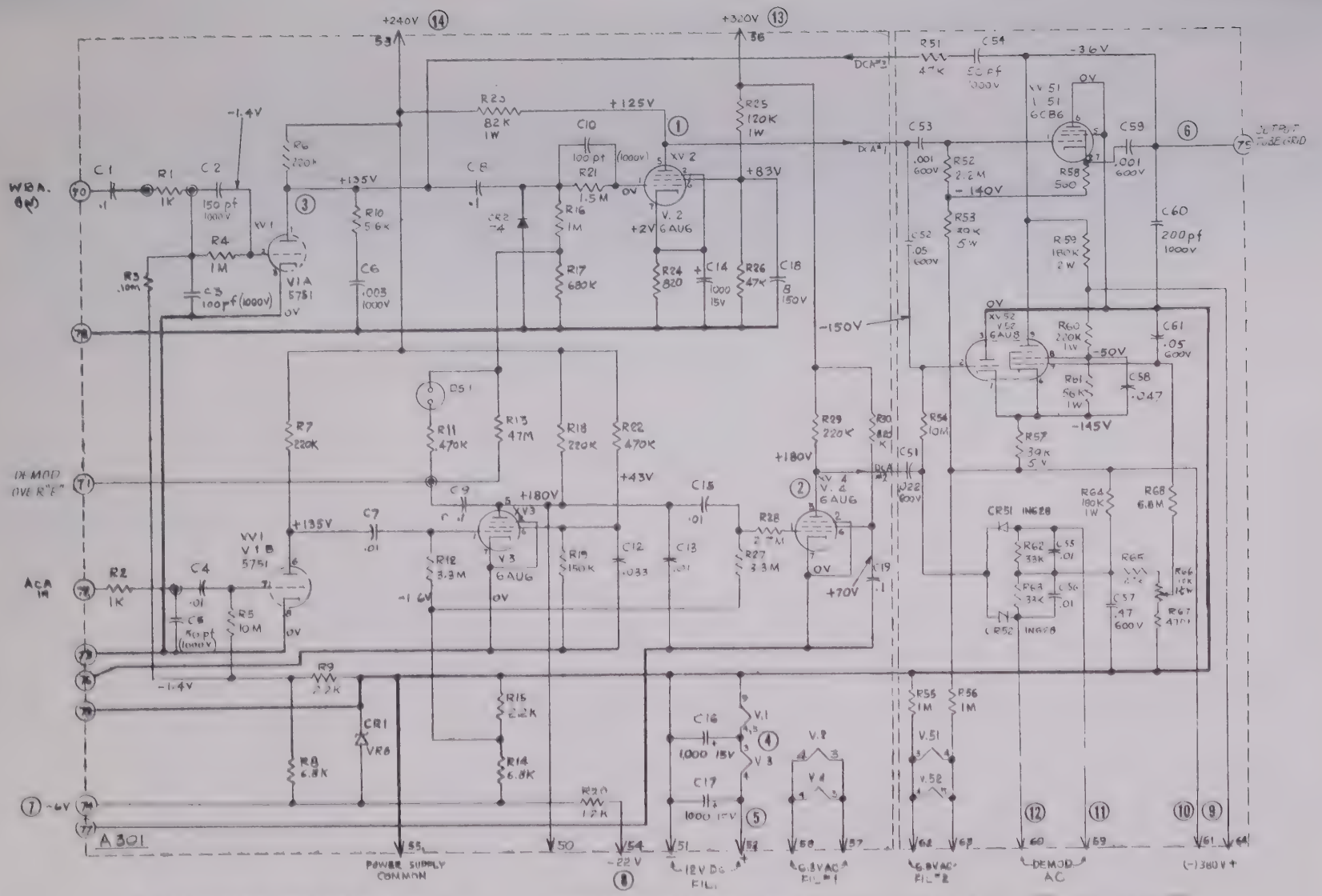


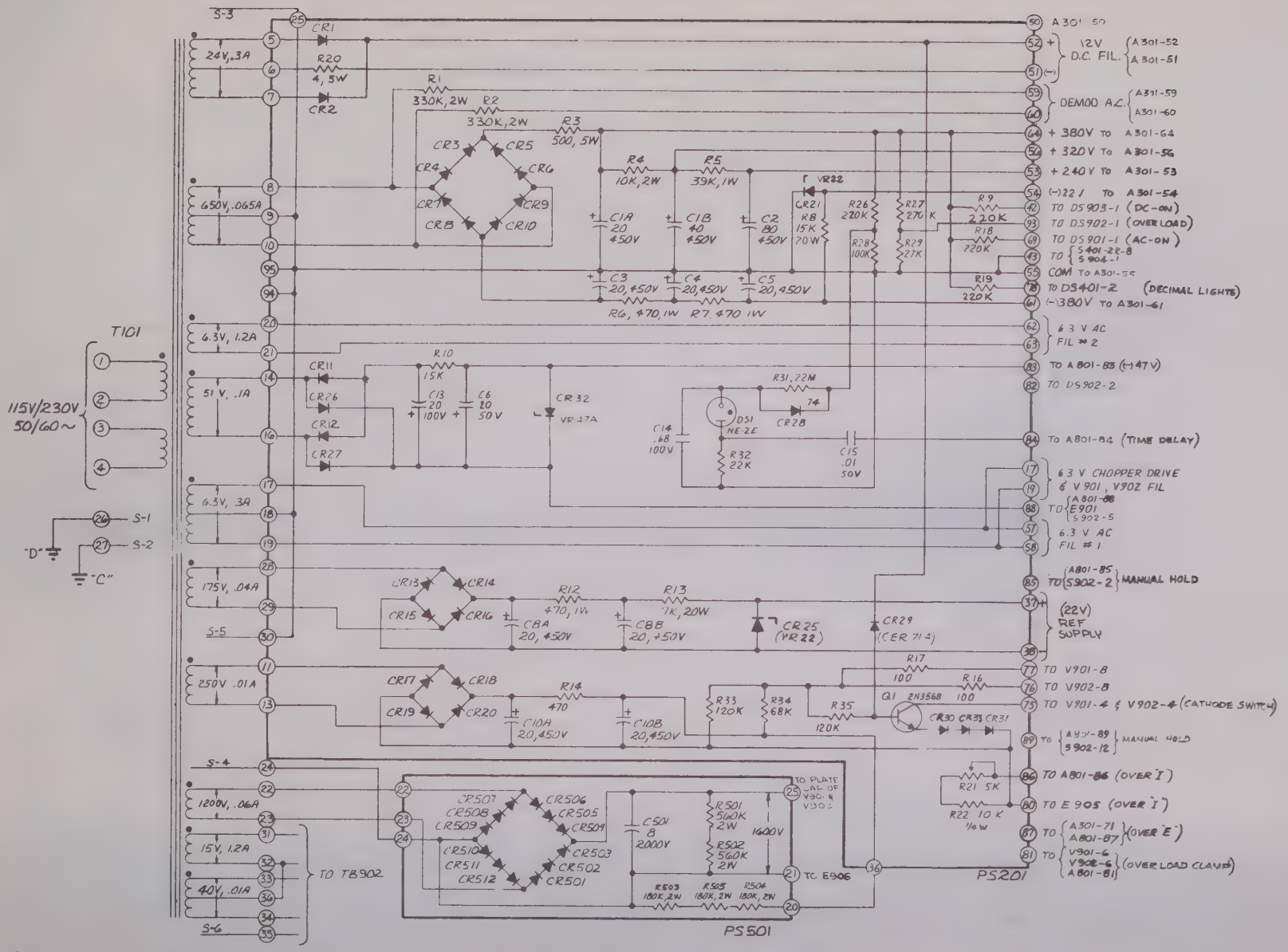
Figure 4-13. Range and Feedback-Decade Network Schematic Diagram (Drawing No. D7820011C)



2. CAPACITOR VALUES ARE IN μF, 400V
1. RESISTOR VALUES ARE IN OHMS, 5%, ½W
NOTES: UNLESS OTHERWISE SPECIFIED

4. SEE FIGURES 4-9 AND 4-10 FOR WAVEFORMS AT POINTS (1) THROUGH (14)
3. REFERENCE DESIGNATIONS ARE ABBREVIATED FROM THE 300 SERIES

Figure 4-14. Amplifier Board Schematic Diagram (Drawing No. D7820030A)



2. CAPACITOR VALUES ARE IN μF
1. RESISTOR VALUES ARE IN OHMS, ½W
NOTES: UNLESS OTHERWISE SPECIFIED

5. R9 IS CONNECTED TO THE R26/R28/R31/CR28 JUNCTION IN SOME UNITS PRIOR TO S/N 1-0201
4. PS201 REFERENCE DESIGNATIONS ARE ABBREVIATED FROM THE 200 SERIES
3. DIODES ARE TYPE CER71A

Figure 4-15. Power Supply Boards Schematic Diagram (Drawing No. D7820021E)

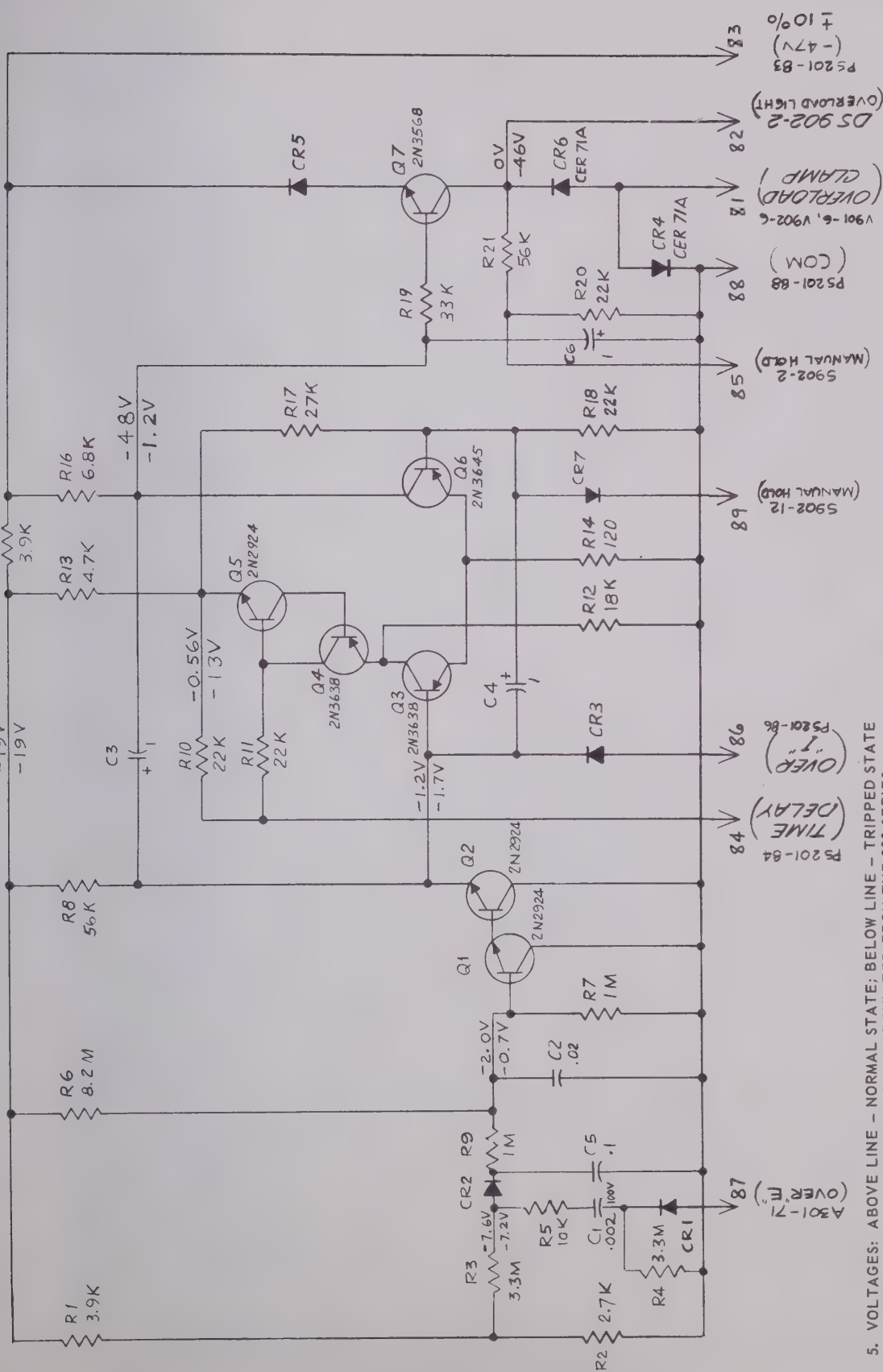
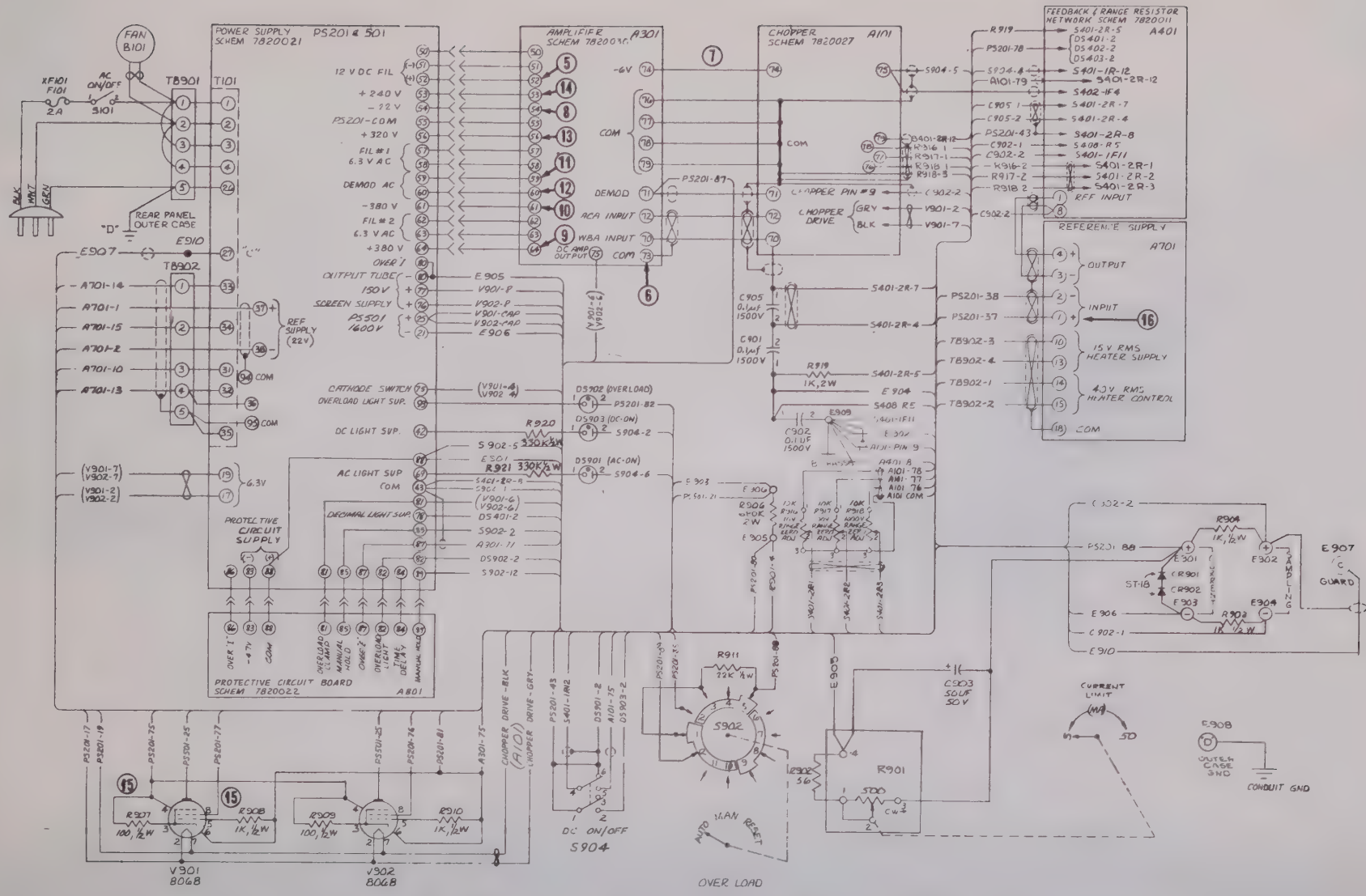


Figure 4-16. Protective Circuit Board Schematic Diagram (Drawing No. D7820022D)



2. ALL WAVEFORMS ARE REFERENCED TO CIRCUIT COMMON EXCEPT (15)
1. RESISTOR VALUES ARE IN OHMS
NOTES: UNLESS OTHERWISE SPECIFIED

4. SOME UNITS ARE NOT EQUIPPED WITH R920 AND R921
3. SEE FIGURES 4-9 AND 4-10 FOR WAVEFORMS AT POINTS (5) THROUGH (16)

Figure 4-17. Main Schematic Diagram (Drawing No. D7820100D)

Table 4-1. Replacement Parts

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
A 101	ASSEMBLY, CHOPPER BOARD	7820026-001
A 301	ASSEMBLY, AMPLIFIER BOARD	7820031-001
A 401	ASSEMBLY, RANGE AND DECADE RESISTORS	7818003-001
A 701	ASSEMBLY, REFERENCE VOLTAGE	7818069-003
A 801	ASSEMBLY, PROTECTIVE CIRCUIT BOARD	7820023-001
B 101	FAN, 100 CFM, 115-120V, 60 HZ	3110023-002
C 201	CAPACITOR, ELECTROLYTIC, 40/20UF, 450V	0510121-006
C 202	CAPACITOR, ELECTROLYTIC, 80 UF, 450V	0510121-005
C 203	CAPACITOR, ELECTROLYTIC, 20 UF, 450V	0510122-002
C 204	CAPACITOR, ELECTROLYTIC, 20 UF, 450V	0510122-002
C 205	CAPACITOR, ELECTROLYTIC, 20 UF, 450V	0510122-002
C 206	CAPACITOR, ELECTROLYTIC, 20UF, 50V	0510124-013
C 208	CAPACITOR, ELECTROLYTIC, 20/20 UF, 450V	0510122-007
C 210	CAPACITOR, ELECTROLYTIC, 20/20 UF, 450V	0510122-007
C 213	CAPACITOR, ELECTROLYTIC, 20UF, 100V	0510124-050
C 214	CAPACITOR, MYLAR, .68UF, 100V	0610109-118
C 215	CAPACITOR, CERAMIC, .01UF, 50V	0410009-903
C 301	CAPACITOR, POLYSTYRENE,.1UF, 400V	0610067-104
C 302	CAPACITOR, CERAMIC DISC, 150PF, 1KV	0401025
C 303	CAPACITOR, CERAMIC DISC, 100PF, 1KV	0401022
C 304	CAPACITOR, POLYSTYRENE, .01UF, 400V	0610067-103
C 305	CAPACITOR, CERAMIC DISC, 50PF, 1KV	0401016
C 306	CAPACITOR, CERAMIC DISC, .0033UF, 500V	0401051
C 307	CAPACITOR, MYLAR, .01UF, 400V	0610018-015
C 308	CAPACITOR, MYLAR, .10UF, 400V	0610018-027
C 309	CAPACITOR, MYLAR, .10UF, 400V	0610018-027
C 310	CAPACITOR, CERAMIC DISC, 100PF, 1KV	0401022
C 312	CAPACITOR, MYLAR, .033UF, 400V	0610018-021
C 313	CAPACITOR, MYLAR, .01UF, 400V	0610018-015
C 314	CAPACITOR, ELECTROLYTIC, 1000UF, 15V	0510061-022
C 315	CAPACITOR, MYLAR, .01UF, 400V	0610018-015
C 316	CAPACITOR, ELECTROLYTIC, 1000UF, 15V	0510061-022
C 317	CAPACITOR, ELECTROLYTIC, 1000UF, 15V	0510061-022
C 318	CAPACITOR, ELECTROLYTIC, 8UF, 150V	0510107-001
C 319	CAPACITOR, MYLAR, .10UF, 400V	0610018-027
C 351	CAPACITOR, MYLAR, .022UF, 600V	0610019-019
C 352	CAPACITOR, MYLAR, .047UF, 600V	0610019-023
C 353	CAPACITOR, MYLAR, .001UF, 600V	0610019-005
C 354	CAPACITOR, CERAMIC DISC, 50PF, 1KV	0401016
C 355	CAPACITOR, MYLAR, .01UF, 400V	0610018-015
C 356	CAPACITOR, MYLAR, .01UF, 400V	0610018-015
C 357	CAPACITOR, MYLAR, .47UF, 600V	0610023-035
C 358	CAPACITOR, MYLAR, .047UF, 400V	0610018-023
C 359	CAPACITOR, MYLAR, .001UF, 600V	0610019-005
C 360	CAPACITOR, CERAMIC DISC, 200PF, 1KV	0401027
C 361	CAPACITOR, MYLAR, .047UF, 600V	0610019-023
C 501	CAPACITOR, PLASTIC, 8 UF, 2KV	0810013-001
C 801	CAPACITOR, CERAMIC, .002UF, 100V	0410015-202
C 802	CAPACITOR, CERAMIC, .02UF, 50V	0410009-203

Table 4-1. Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
C 803	CAPACITOR, TANTALUM, 1UF, 50V	0510145-002
C 804	CAPACITOR, TANTALUM, 1UF, 50V	0510145-002
C 805	CAPACITOR, CERAMIC, .1 UF, 50V	0410009-104
C 806	CAPACITOR, TANTALUM, 1UF, 50V	0510145-002
C 901	CAPACITOR, POLYSTYRENE, .1 UF, 1500 V	0610108-002
C 902	CAPACITOR, POLYSTYRENE, .1 UF, 1500 V	0610108-002
C 903	CAPACITOR, ELECTROLYTIC, 50UF, 50V	0510124-015
C 905	CAPACITOR, POLYSTYRENE, .1 UF, 1500 V	0610108-002
CR 101	DIODE, SILICON, TYPE HC71	3510053-005
CR 102	DIODE, SILICON, TYPE HC71	3510053-005
CR 201	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 202	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 203	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 204	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 205	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 206	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 207	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 208	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 209	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 210	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 211	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 212	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 213	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 214	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 215	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 216	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 217	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 218	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 219	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 220	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 221	DIODE, ZENER, TYPE VR22	3510049-016
CR 225	DIODE, ZENER, TYPE VR22	3510049-016
CR 226	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 227	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 228	DIODE, SILICON, TYPE 74	3510050-001
CR 229	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 230	DIODE, SILICON, TYPE 74	3510050-001
CR 231	DIODE, SILICON, TYPE 74	3510050-001
CR 232	DIODE, ZENER, TYPE VR47A	3510049-015
CR 233	DIODE, SILICON, TYPE 74	3510050-001
CR 301	DIODE, ZENER, TYPE VR6	3510049-017
CR 302	DIODE, SILICON, TYPE 74	3510050-001
CR 351	DIODE, SILICON, TYPE 1N628	3510004
CR 352	DIODE, SILICON, TYPE 1N628	3510004
CR 501	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 502	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 503	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 504	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 505	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001

Table 4-1. Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
CR 506	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 507	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 508	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 509	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 510	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 511	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 512	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 801	DIODE, SILICON, TYPE 74	3510050-001
CR 802	DIODE, SILICON, TYPE 74	3510050-001
CR 803	DIODE, SILICON, TYPE 74	3510050-001
CR 804	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 805	DIODE, SILICON, TYPE 74	3510050-001
CR 806	DIODE, SILICON RECTIFIER, TYPE CER71A	3510053-001
CR 807	DIODE, SILICON, TYPE 74	3510050-001
CR 901	DIODE, RECTIFIER, TYPE ST-18	3510068-004
CR 902	DIODE, RECTIFIER, TYPE ST-18	3510068-004
DS 201	LAMP, NEON, TYPE NE-2	1704151
DS 301	LAMP, NEON, TYPE NE-2	1704151
DS 401	INDICATOR LAMP ASSEMBLY	1710152-003
DS 402	INDICATOR LAMP ASSEMBLY	1710152-003
DS 403	INDICATOR LAMP ASSEMBLY	1710152-003
DS 901	INDICATOR LAMP ASSEMBLY	1710152-003
DS 902	INDICATOR LAMP ASSEMBLY	1710152-003
DS 903	INDICATOR LAMP ASSEMBLY	1710152-003
F 101	FUSE, CARTRIDGE, 3AG SLO-BLO, 2.00 AMP	1710040-024
G 101	CHOPPER, TYPE CH801-50/60	6310018-001
PS 201	ASSEMBLY, POWER SUPPLY BOARD	7820020-001
PS 501	ASSEMBLY, HIGH VOLTAGE POWER SUPPLY BOARD	7817041-001
Q 201	TRANSISTOR, TYPE 2N3568	7210069-003
Q 801	TRANSISTOR, TYPE 2N2924	7210056-003
Q 802	TRANSISTOR, TYPE 2N2924	7210056-003
Q 803	TRANSISTOR, TYPE 2N3638	7210069-001
Q 804	TRANSISTOR, TYPE 2N3638	7210069-001
Q 805	TRANSISTOR, TYPE 2N2924	7210056-003
Q 806	TRANSISTOR, TYPE 2N3645	7210069-004
Q 807	TRANSISTOR, TYPE 2N3568	7210069-003
R 101	RESISTOR, 1/2 WATT, 5%, 22 KILOHM	0310030-223
R 102	RESISTOR, 1/2 WATT, 5%, 10 MEGOHM	0310030-106
R 103	RESISTOR, 1/2 WATT, 5%, 560 KILOHM	0310030-564
R 104	RESISTOR, 2 WATT, 5%, 10 KILOHM	0310032-103
R 105	RESISTOR, 1/2 WATT, 5%, 47 OHM	0310030-470
R 106	RESISTOR, 1/2 WATT, 5%, 820 KILOHM	0310030-824
R 107	RESISTOR, 1/2 WATT, 5%, 100 OHM	0310030-101
R 108	RESISTOR, 1/2 WATT, 5%, 560 KILOHM	0310030-564
R 109	RESISTOR, 1/2 WATT, 5%, 220 OHM	0310030-221
R 110	RESISTOR, 1/2 WATT, 5%, 270 KILOHM	0310030-274
R 201	RESISTOR, 2 WATT, 5%, 330 KILOHM	0310032-334
R 202	RESISTOR, 2 WATT, 5%, 330 KILOHM	0310032-334
R 203	RESISTOR, WIREWOUND, 5W, 500 OHM	5110010-028

Table 4-1. Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
R 204	RESISTOR, 2 WATT, 5%, 10 KILOHM	0310032-103
R 205	RESISTOR, 1 WATT, 5%, 39 KILOHM	0310031-393
R 206	RESISTOR, 1 WATT, 5%, 470 OHM	0310031-471
R 207	RESISTOR, 1 WATT, 5%, 470 OHM	0310031-471
R 208	RESISTOR, WIREWOUND, 20W, 15 KILOHM	5102102
R 209	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
R 210	RESISTOR, 1/2 WATT, 5%, 1.5 KILOHM	0310030-152
R 212	RESISTOR, 1 WATT, 5%, 470 OHM	0310031-471
R 213	RESISTOR, WIREWOUND, 20W, 7 KILOHM	5102097
R 214	RESISTOR, 1/2 WATT, 5%, 470 OHM	0310030-471
R 216	RESISTOR, 1/2 WATT, 5%, 100 OHM	0310030-101
R 217	RESISTOR, 1/2 WATT, 5%, 100 OHM	0310030-101
R 218	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
R 219	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
R 220	RESISTOR, WIREWOUND, 5W, 4 OHM	5110010-005
R 221	RESISTOR, VARIABLE, 1.25W, 5 KILOHM	5010209-003
R 222	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 226	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
R 227	RESISTOR, 1/2 WATT, 5%, 270 KILOHM	0310030-274
R 228	RESISTOR, 1/2 WATT, 5%, 100 KILOHM	0310030-104
R 229	RESISTOR, 1/2 WATT, 5%, 27 KILOHM	0310030-273
R 231	RESISTOR, 1/2 WATT, 5%, 2.2 MEGOHM	0310030-225
R 232	RESISTOR, 1/2 WATT, 5%, 22 KILOHM	0310030-223
R 233	RESISTOR, 1/2 WATT, 5%, 120 KILOHM	0310030-124
R 234	RESISTOR, 1/2 WATT, 5%, 68 KILOHM	0310030-683
R 235	RESISTOR, 1/2 WATT, 5%, 120 KILOHM	0310030-124
R 301	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
R 302	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
R 303	RESISTOR, 1/2 WATT, 5%, 10 MEGOHM	0310030-106
R 304	RESISTOR, 1/2 WATT, 5%, 1 MEGOHM	0310030-105
R 305	RESISTOR, 1/2 WATT, 5%, 10 MEGOHM	0310030-106
R 306	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
R 307	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
R 308	RESISTOR, 1/2 WATT, 5%, 6.8 KILOHM	0310030-682
R 309	RESISTOR, 1/2 WATT, 5%, 2.2 KILOHM	0310030-222
R 310	RESISTOR, 1/2 WATT, 5%, 5.6 KILOHM	0310030-562
R 311	RESISTOR, 1/2 WATT, 5%, 470 KILOHM	0310030-474
R 312	RESISTOR, 1/2 WATT, 5%, 3.3 MEGOHM	0310030-335
R 313	RESISTOR, 1/2 WATT, 5%, 4.7 MEGOHM	0310030-475
R 314	RESISTOR, 1/2 WATT, 5%, 6.8 KILOHM	0310030-682
R 315	RESISTOR, 1/2 WATT, 5%, 2.2 KILOHM	0310030-222
R 316	RESISTOR, 1/2 WATT, 5%, 1 MEGOHM	0310030-105
R 317	RESISTOR, 1/2 WATT, 5%, 680 KILOHM	0310030-684
R 318	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
R 319	RESISTOR, 1/2 WATT, 5%, 150 KILOHM	0310030-154
R 320	RESISTOR, 1/2 WATT, 5%, 1.2 KILOHM	0310030-122
R 321	RESISTOR, 1/2 WATT, 5%, 1.5 MEGOHM	0310030-155
R 322	RESISTOR, 1/2 WATT, 5%, 470 KILOHM	0310030-474
R 323	RESISTOR, 1 WATT, 5%, 82 KILOHM	0310031-823

Table 4-1. Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
R 324	RESISTOR, 1/2 WATT, 5%, 820 OHM	0310030-821
R 325	RESISTOR, 1 WATT, 5%, 120 KILOHM	0310031-124
R 326	RESISTOR, 1/2 WATT, 5%, 47 KILOHM	0310030-473
R 327	RESISTOR, 1/2 WATT, 5%, 3.3 MEGOHM	0310030-335
R 328	RESISTOR, 1/2 WATT, 5%, 2.7 MEGOHM	0310030-275
R 329	RESISTOR, 1/2 WATT, 5%, 220 KILOHM	0310030-224
R 330	RESISTOR, 1/2 WATT, 5%, 820 KILOHM	0310030-824
R 351	RESISTOR, 1/2 WATT, 5%, 47 KILOHM	0310030-473
R 352	RESISTOR, 1/2 WATT, 5%, 2.2 MEGOHM	0310030-225
R 353	RESISTOR, WIREWOUND, 5W, 39 KILOHM	5110030-001
R 354	RESISTOR, 1/2 WATT, 5%, 10 MEGOHM	0310030-106
R 355	RESISTOR, 1/2 WATT, 5%, 1 MEGOHM	0310030-105
R 356	RESISTOR, 1/2 WATT, 5%, 1 MEGOHM	0310030-105
R 357	RESISTOR, WIREWOUND, 5W, 39 KILOHM	5110030-001
R 358	RESISTOR, 1/2 WATT, 5%, 560 OHM	0310030-561
R 359	RESISTOR, 2 WATT, 5%, 180 KILOHM	0310032-184
R 360	RESISTOR, 1 WATT, 5%, 220 KILOHM	0310031-224
R 361	RESISTOR, 1 WATT, 5%, 56 KILOHM	0310031-563
R 362	RESISTOR, 1/2 WATT, 5%, 33 KILOHM	0310030-333
R 363	RESISTOR, 1/2 WATT, 5%, 33 KILOHM	0310030-333
R 364	RESISTOR, 1 WATT, 5%, 180 KILOHM	0310031-184
R 365	RESISTOR, 1/2 WATT, 5%, 47 KILOHM	0310030-473
R 366	RESISTOR, VARIABLE, 1.25W, 10 KILOHM	5010209-004
R 367	RESISTOR, 1/2 WATT, 5%, 470 KILOHM	0310030-474
R 368	RESISTOR, 1/2 WATT, 5%, 6.8 MEGOHM	0310030-685
R 408	RESISTOR, VARIABLE, 1W, 50 OHM	5010200-203
R 411	RESISTOR, VARIABLE, 1W, 20 OHM	5010200-202
R 412	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-008
R 413	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-008
R 414	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-007
R 415	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-007
R 416	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-016
R 417	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-017
R 418	RESISTOR, PRECISION, .005%, 200 OHM	5210100-018
R 419	RESISTOR, PRECISION, .005%, 100 OHM	5210100-017
R 420	RESISTOR, PRECISION, .01%, 20 OHM	5210100-009
R 421	RESISTOR, PRECISION, .01%, 10 OHM	5210100-008
R 422	RESISTOR, PRECISION, .1%, 2 OHM	5210100-012
R 423	RESISTOR, PRECISION, .1%, 1 OHM	5210100-011
R 424	RESISTOR, VARIABLE, 1W, 100 OHM	5010200-204
R 427	RESISTOR, VARIABLE, 1W, 100 OHM	5010200-204
R 428	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-009
R 429	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-009
R 430	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-009
R 431	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-009
R 432	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-018
R 433	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-018
R 434	RESISTOR, PRECISION, .005%, 400 OHM	5210100-019
R 435	RESISTOR, PRECISION, .005%, 400 OHM	5210100-019

Table 4-1. Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
R 436	RESISTOR, PRECISION, .01%, 40 OHM	5210100-010
R 437	RESISTOR, PRECISION, .01%, 40 OHM	5210100-010
R 438	RESISTOR, PRECISION, .1%, 4 OHM	5210100-013
R 439	RESISTOR, PRECISION, .1%, 4 OHM	5210100-013
R 440	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-016
R 441	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-017
R 442	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-018
R 443	RESISTOR ASSEMBLY, ADJUSTABLE	7817427-018
R 444	RESISTANCE WIRE, .2 OHM	7610036-002
R 445	RESISTANCE WIRE, .1 OHM	7610036-002
R 446	RESISTANCE WIRE, .4 OHM	7610036-002
R 447	RESISTANCE WIRE, .4 OHM	7610036-002
R 448	RESISTOR, 1/2W, 5%, 330 KILOHM	0310030-334
R 449	RESISTOR, 1/2W, 5%, 330 KILOHM	0310030-334
R 450	RESISTOR, 1/2W, 5%, 330 KILOHM	0310030-334
R 501	RESISTOR, 2 WATT, 5%, 560 KILOHM	0310032-564
R 502	RESISTOR, 2 WATT, 5%, 560 KILOHM	0310032-564
R 503	RESISTOR, 2 WATT, 5%, 180 KILOHM	0310032-184
R 504	RESISTOR, 2 WATT, 5%, 180 KILOHM	0310032-184
R 505	RESISTOR, 2 WATT, 5%, 180 KILOHM	0310032-184
R 801	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 802	RESISTOR, CARBON, 1/4W, 5%, 2.7 KILOHM	4045000-272
R 803	RESISTOR, CARBON, 1/4W, 5%, 3.3 MEGOHM	4045000-335
R 804	RESISTOR, CARBON, 1/4W, 5%, 3.3 MEGOHM	4045000-335
R 805	RESISTOR, CARBON, 1/4W, 5%, 10 KILOHM	4045000-103
R 806	RESISTOR, CARBON, 1/4W, 5%, 8.2 MEGOHM	4045000-825
R 807	RESISTOR, CARBON, 1/4W, 5%, 1.0 MEGOHM	4045000-105
R 808	RESISTOR, CARBON, 1/4W, 5%, 56 KILOHM	4045000-563
R 809	RESISTOR, CARBON, 1/4W, 5%, 1.0 MEGOHM	4045000-105
R 810	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 811	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 812	RESISTOR, CARBON, 1/4W, 5%, 18 KILOHM	4045000-183
R 813	RESISTOR, CARBON, 1/4W, 5%, 4.7 KILOHM	4045000-472
R 814	RESISTOR, CARBON, 1/4W, 5%, 120 OHM	4045000-121
R 815	RESISTOR, CARBON, 1/4W, 5%, 3.9 KILOHM	4045000-392
R 816	RESISTOR, CARBON, 1/4W, 5%, 6.8 KILOHM	4045000-682
R 817	RESISTOR, CARBON, 1/4W, 5%, 27 KILOHM	4045000-273
R 818	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 819	RESISTOR, CARBON, 1/4W, 5%, 33 KILOHM	4045000-333
R 820	RESISTOR, CARBON, 1/4W, 5%, 22 KILOHM	4045000-223
R 821	RESISTOR, CARBON, 1/4W, 5%, 56 KILOHM	4045000-563
R 901	RESISTOR, VARIABLE, 500 OHM	5010098-001
R 902	RESISTOR, 1/2 WATT, 5%, 56 OHM	0310030-560
R 903	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
R 904	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
R 906	RESISTOR, 2 WATT, 5%, 680 KILOHM	0310032-684
R 907	RESISTOR, 1/2 WATT, 5%, 100 OHM	0310030-101
R 908	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102
R 909	RESISTOR, 1/2 WATT, 5%, 100 OHM	0310030-101
R 910	RESISTOR, 1/2 WATT, 5%, 1 KILOHM	0310030-102

Table 4-1. Replacement Parts (Contd)

CIRCUIT REF.	DESCRIPTION	COHU PART NO.
R 911	RESISTOR, 1/2 WATT, 5%, 22 KILOHM	0310030-223
R 916	RESISTOR, VARIABLE, 1/2W, 10 KILOHM	5010181-003
R 917	RESISTOR, VARIABLE, 1/2W, 10 KILOHM	5010181-003
R 918	RESISTOR, VARIABLE, 1/2W, 10 KILOHM	5010181-003
R 919	RESISTOR, 2 WATT, 5%, 1 KILOHM	0310032-102
R 920	RESISTOR, 1/2W, 5%, 330 KILOHM	0310030-334
R 921	RESISTOR, 1/2W, 5%, 330 KILOHM	0310030-334
S 101	SWITCH, ROTARY, SPST	6210018-003
S 401	SWITCH, ROTARY, 5P3T, SHORTING	6210133-001
S 402	SWITCH, ROTARY, 4-4-2-1 BCD, SHORTING	6210136-002
S 403	SWITCH, ROTARY, 4-4-2-1 BCD, SHORTING	6210136-002
S 404	SWITCH, ROTARY, 4-4-2-1 BCD, SHORTING	6210136-002
S 405	SWITCH, ROTARY, 4-4-2-1 BCD, SHORTING	6210136-002
S 406	SWITCH, ROTARY, 4-4-2-1 BCD, SHORTING	6210136-002
S 407	SWITCH, ROTARY, 4-4-2-1 BCD, SHORTING	6210136-002
S 408	SWITCH, ROTARY, 4-4-2-1 BCD, SHORTING	6210136-002
S 902	SWITCH, ROTARY, 3P3T, NON SHORTING	6210134-001
S 904	SWITCH, ROTARY, DPDT, NON SHORTING	6210151-001
T 101	TRANSFORMER, POWER, 115/230V, 50/60 HZ	7820019-001
V 301	ELECTRON TUBE, TYPE 5751	7302812
V 302	ELECTRON TUBE, TYPE 6AU6A GE	7010041-001
V 303	ELECTRON TUBE, TYPE 6AU6A GE	7010041-001
V 304	ELECTRON TUBE, TYPE 6AU6A GE	7010041-001
V 351	ELECTRON TUBE, TYPE 6CB6A RCA	7002773
V 352	ELECTRON TUBE, TYPE 6AU8A	7007118
V 901	ELECTRON TUBE, TYPE 8068	7010045-001
V 902	ELECTRON TUBE, TYPE 8068	7010045-001

WARRANTY

COHU ELECTRONICS, INC., warrants equipment manufactured to be free from defects of material and workmanship. Any part or parts will be repaired or replaced when proven by COHU examination to have been defective within one year (90 days for batteries, fuses, transistors and tubes) from date of shipment to the original purchaser. All warranty repairs will be performed at the factory or as otherwise authorized by COHU in writing. Transportation charges shall be prepaid by purchaser.

This warranty does not extend to COHU equipment subjected to misuse, accident, neglect or improper application; nor repaired or altered by other than COHU or those authorized by COHU in writing.

This warranty is in lieu of all other warranties express or implied. COHU shall not be liable for collateral or consequential damages.

For customer convenience, service departments are maintained throughout the United States by COHU Field Engineering Representatives.

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